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Cephalopods of the Pierre Formation of Wallace County, Kansas, and Adjacent Area

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ABSTRACT: The paper is devoted chiefly to the description and to the discussion of stratigraphic value of some of the Upper Cretaceous ammonoids of the *Baculites* and *Scaphites* group in western Kansas and adjacent part of Colorado.

The following new names are introduced:

Baculites pseudovatus Elias, n. sp.
Baculites pseudovatus var. *A.* Elias, n. var.
Baculites compressus var. *reesidei* Elias, n. var.
Baculites compressus var. *corrugatus* Elias, n. var.
Baculites clinolobatus Elias, n. sp.
Baculites meeki Elias, n. sp.
Discoscaphites nicolleti var. *saltgrassensis* Elias n. var.

The specific name *compressus* Say is very narrowly restricted to the topotype of the species *Baculites compressus* as described by Meek (1854, 1876). *Scaphites nodosus* var. *plenus* Meek is removed from the *Acantoscaphites nodosus* group and is elevated to the rank of species of the genus *Scaphites* sensu stricto: *Scaphites plenus* (Meek).

INTRODUCTION

AMMONITES of both coiled and uncoiled types are among the most abundant fossils in the Pierre of northwestern Kansas. Some genera and species of this order are the most important horizon-markers of the local subdivisions of the Pierre, and a few of them are of great importance for the correlation of the formation with the contemporaneous beds in eastern North America and Europe. Owing to this fact the writer devoted more time and care to the study of these invertebrates than of the other marine fossils of the formation. It is intended to describe the latter in a forthcoming separate paper.

The writer wishes to acknowledge valuable suggestions and criticism by Dr. R. C. Moore and Dr. J. B. Reeside, Jr., which helped considerably in precise identification and in elaborating the description of the species.

STRATIGRAPHIC RANGE OF THE DESCRIBED SPECIES

In the following tables the stratigraphic distribution of the ammonites herein described and a few others are shown. The distribution in space and time of the most important of these forms is also shown on the stratigraphic table of the geological report on Wallace county (Bull. 18, State Geological Survey of Kansas, 1931).

METHOD OF DRAWING SUTURES OF *BACULITES* AND OTHER AMMONOIDEA

In preparing the sketches of the sutures of *Baculites* and other Ammonoidea of the Pierre two methods were used. The larger sutures were traced directly on cellophane, which was wrapped around a portion of a fossil. In order to add visibility and avoid mistakes in tracing, the space between two neighboring sutures was painted with black India ink. A fine drafting pen was used for painting the minute dentations of the sutures. Cellophane is preferable to other transparent material (celluloid film, wax paper, tracing cloth, etc.) because it is perfectly transparent, and, being soft and flexible, can be pressed more tightly against the uneven surface of the variously sculptured molds of ammonoids. The India ink sticks to cellophane fairly well, and fine lines can be drawn on it. However, when drawing a line over those places where the cellophane is not quite firmly pressed against the surface of the fossil, one inevitably scratches the soft tissue with the sharp point of

	Sharon Springs shale member		Weskan shale member		Lake Creek shale member		Salt Grass shale member		Undifferentiated shale	Beecher Island shale member
	Lower	Upper	Lower	Upper	Lower	Upper	Lower	Middle		
Baculites aquilarnsis var. *separatus* Reeside		x(?)								
Baculites ovatus var. *haresi* Reeside				x						
Baculites pseudovatus Elias, n. sp				x	x					
Baculites pseudovatus var. A Elias, n. var							x	x		
Baculites compressus Say, emend. Meek				x	x	x				
Baculites compressus var. *reesidei* Elias, n. var					x	x	x	x		
Baculites compressus var. *corrugatus* Elias, n. var						x	x			
Baculites clinolobatus Elias, n. sp										x
Baculites grandis Hall and Meek									x	x
Baculites meeki Elias, n. sp										x

	Sharon Springs shale member		Weskan shale member		Lake Creek shale member		Salt Grass shale member			Undiffer-entiated shale	Beecher Island shale member
	Lower	Upper	Lower	Upper	Lower	Upper	L	M	U		
Heteroceras tortum Meek & Hayden	....	x	....	....	....	....	......	......	......	....	....
Placenticeras meeki Boehm	....	....	x	x	x	....	......	......	......	....	....
Acanthoscaphites nodosus Owen	....	....	....	x	x	x	......	......	......	....	....
Acanthoscaphites nodosus var. *brevis* Meek	....	....	....	x	x	x	x	......	......	....	....
Acanthoscaphites nodosus var. *quadrangularis* Meek & Hayden	....	....	....	x	x	x	x	......	......	....	....
Acanthoscaphites (?) *reesidei* Wade	....	....	....	....	....	....	x	......	......	....	....
Scaphites plenus Meek	....	....	....	....	....	....	x	......	......	....	....
cf. *Discoscaphites constrictus* var. *tenuistriatus* (Kner)	....	....	x	....	....	x	......	......	......	....	....
Discoscaphites nicolleti var. *saltgrassensis* Elias. n. var	....	....	....	....	....	....	......	......	x	....	....
Discoscaphites conradi (Morton)	....	....	....	....	....	....	......	......	......	....	x
Discoscaphites abyssinus (Morton)	....	....	....	....	....	....	......	......	......	....	x

the pen. Owing to this the lines soon become too heavy to express the finer details of the sutures. The writer found that it is much safer and more convenient not to trace on cellophane the suture lines themselves, but to ink in the space on one side of a suture.

The next operation is the final tracing from the cellophane drawing. Due to slight warping of the cellophane painted with India ink, the use of a light-table (table with glass top illuminated from below) is recommended. If desirable the cellophane copy can be enlarged by photography and the final tracing of the suture can be made from the photograph. In view of the desirability of having the drawings two times larger than the proposed size of printed illustrations the enlargement by photography is ordinarily preferable.

For the tracing of very small and complicated sutures the method of direct tracing on cellophane is too crude. For drafting of the sutures of juvenile stages of *Baculites* and, also, of the sutures of smaller coiled scaphites, the writer used a camera-lucida attached to a microscope. In order to draw an undistorted suture on a plane, several settings of the specimen must be made. For a curved surface of about 180 degrees, or half way around a shell, the writer made six or seven settings. After a part of a suture is copied, the fossil is turned so as to have the next portion of the suture nearly perpendicular to the axis of the microscope. In order not to depart from a constant orientation of the shell one must revolve it around the same or nearly the same axis, and in order to make proper connection of two neighboring portions of a suture the comparatively undistorted edges of the drawings of the two must somewhat overlap each other. The smallest magnification of ordinary microscopes used in paleontological laboratories with attached camera-lucida is about 10 times and, therefore, the drawn suture is usually too large and must be reduced. This can be done by photography or by a pantograph.

All of the sutures of *Baculites* shown on the accompanying plates were drawn by the direct method of tracing on cellophane, except Plate XXXV, figures 5d, 5e, which were drawn with the help of camera-lucida and subsequently reduced by pantograph. All the sutures of the *Scaphites* group were drawn with the help of camera-lucida and reduced by photography.

DESCRIPTION OF THE SPECIES

CLASS CEPHALOPODA—SUBCLASS TETRABRANCHIATA

ORDER AMMONOIDEA—SUBORDER EXTRASIPHONATA

FAMILY LYTOCERATIDÆ

SUBFAMILY MACROSCAPHITINÆ

Genus BACULITES Lamarck

"Shell with minute, closely coiled initial stage but quickly becoming straight and assuming the form of a staff which, with increasing age, increases slowly in diameter. Cross section subtriangular, oval, or subcircular, though usually more or less compressed laterally. Living chamber large, aperture with long, straight, rounded extension on the siphonal side and lateral sinuses. Surface smooth or with low rounded ribs that are parallel to the aperture and as a rule are distinct only on the flanks, or with low rounded nodes on the flanks. Suture has generally six saddles and six lobes; saddles bifid; lobes, except the antisiphonal lobe, bifid."[1]

Genotype. *Baculites vertebralis* Lamarck (Syst. des anim., p. 103).

The remains of *Baculites,* chiefly in the form of internal molds. are perhaps the most abundant fossils of the Pierre shale in Wallace county and elsewhere. The common smooth specimens from this formation are ordinarily referred to *Baculites ovatus* Say and *B. compressus* Say, which were instituted on material from the Upper Cretaceous of New Jersey and Upper Missouri river, respectively. Unfortunately, a clear conception of these species was not given in the original descriptions, and considerable confusion as to which features are typical for each species was thus created. In addition, the type specimens of *B. compressus* are lost. For the clearing up of the question as to which features must be considered typical for each of the two species, we owe much to F. B. Meek and J. B. Reeside, Jr. The latter author has pointed out that *B. compressus* of some authors (Morton, Whitfield) is not the *B. compressus* of Meek, but is a slightly compressed variety of *B. ovatus.* He furthermore has suggested acceptance of Meek's clear conception of *B. compressus,* based on topotypes of the species. Reeside proposes to separate the forms which have a suture closely resembling that of *B. ovatus,* but which have a somewhat compressed cross section resembling that of *B. compressus,* as *Baculites ovatus* var. *haresi* Reeside.

The writer collected chiefly from the middle and lower part of

1. After Reeside, 1927, p. 9.

the Pierre and from the topmost beds of this formation and found a considerable variety of forms closely related to *B. compressus* and *B. ovatus*. Among these are several specimens with the ovate cross section of the *B. ovatus* type, but with the suture, though not quite identical, nevertheless decidedly of the *B. compressus* type. He considers it preferable to give this form the new specific name *B. pseudovatus*, a new variety of which (*B. pseudovatus* var. A) is also provisionally recognized by him. The writer found numerous specimens which are identical with *B. compressus*, as described by Reeside,[2] in every respect, including the pronounced and regular corrugation of the siphonal edge. At the same time the writer collected from somewhat different horizons of the Pierre a few specimens indistinguishable from *B. compressus* as described by Meek and having only a slightly corrugated siphonal edge. He noticed, furthermore, that the sutures of the *B. compressus* Meek are more digitate than those of *B. compressus* Reeside. He distinguishes the form described by Reeside as *B. compressus* var. *reesidei* and recognizes in his material from Wallace county another variety with still more prominent corrugation of the siphonal side, which he designates as *B. compressus* var. *corrugatus*. This form has also some definite pecularities of the suture and its vertical range is much restricted.

The writer is aware that one may question the differentiation of so many species and varieties among forms which until recently were referred to only two species: *B. compressus* and *B. ovatus*. To this the writer answers that, besides the observed differences in form and suture, the definite stratigraphic position of these forms in the local Pierre section (as shown on the table, p. 297) justifies their record under separate names. It is possible that some of these varieties are mere responses of the species to local changes in the environments of the Pierre sea; but, at any rate, these forms appear to be of local stratigraphic value as horizon markers. On the other hand, some of the forms may prove to have wide stratigraphic importance and may help considerably in the distant correlation of subdivisions of the Pierre and contemporaneous formations, not only in North America but in the Upper Cretaceous formations elsewhere. It is significant that one species of *Baculites* from the Beecher Island shale, comparable in size, cross section, smoothness of the shell and characters of the suture to the *B. ovatus*[3] and *B. compressus* in the broadest sense, was found to be still more similar

2. Reeside, 1927, pp. 10-12.

3. In fact a specimen of this form in the old collection in the Kansas University was identified as *B. ovatus* Say, and another as *B. anceps* Lamarck.

and possibly identical with a specimen of *B. anceps* var. *Leopoliensis* described by Novak from the Upper Cretaceous of Poland. The writer feels that unless the forms commonly referred to *B. ovatus* and *B. compressus* are studied in more detail and are separated into species, subspecies and varieties, in somewhat the same way as has been done by Reeside for the *Baculites* of the Eagle Sandstone and related formations,[4] these widely distributed and important fossils will be of very little help as horizon markers, but will be merely characteristic of the whole Pierre. Furthermore, unless the various intermediate forms are recognized, the types themselves can be hardly treated as distinct species on account of the proven existence of a number of intermediate forms of all kinds; for instance, forms with compressed cross section and moderately digitate suture of the *B. ovatus* type and forms with ovate cross section and intensely digitate suture of the *B. compressus* type. The following is a key for identification of the *Baculites* of the Pierre and related formations.

For convenience of reference in the description of the species of *Baculites* a diagrammatic sketch of a typical suture of the genus is appended (Pl. XL, fig. 7). The suture consists of siphonal or ventral lobe (SL), first (lateral) saddle (1S), first lobe (1L), second saddle (2S), second lobe (2L), third (always small) saddle (3S), and antisiphonal or dorsal lobe (AL). The ventral lobe is very complex and consists of two lateral tripartite branches which are widely separated by a central broad saddle. As a result of his study of material from Wallace county, with the addition of the material illustrated in the literature, the writer concludes that the form and character of incision of this central part of the ventral lobe is of diagnostic value for the species and varieties of the *B. ovatus* and *B. compressus* group. Inasmuch as the terminology for the details of this part of the suture of *Baculites* is not worked out, he proposes the following terms, to which he attaches no biological or orthogenetic significance, but which are introduced for descriptive purposes alone. The whole broad, central portion of the ventral lobe between the two lateral branches is designated as the ventral or siphonal saddle (a term used already by some authors). This saddle is always distinctly subdivided into two smaller lateral saddles and a median saddle (*b*) between. The lateral saddles and median saddle are separated by what Meek described as "smaller digitate lateral branches" of the siphonal lobe. The comparative width of the *siphonal saddle,* the relative width and height of its central branch (*b*) and the character of incision of the latter (uni, bi-, tri-

4. Reeside, 1927.

KEY FOR THE IDENTIFICATION OF THE BACULITES OF THE PIERRE AND RELATED FORMATIONS

Species of Baculites	Size, form and sculpture.					Character of Sutures.				
				Sculpture					Middle branch *b* of siphonal sinus (see pl. XL, Fig. 7).	
	Size (long dia. in millimeters)	Cross section.	Tapering (increase of long dia. per length of shell in millimeters)	Of flanks.	Of siphonal side.	Degree of dissection of lobes.	Stemlike body a supporting terminal branches of first lateral lobe (See pl. xl, fig. 7)	Symmetry and orientation of second lateral lobe	Height in relation to lateral branches	Dissection.
B. ovatus Say	Moderate, to 50 mm. (possibly larger).	Elliptical to ovate.	Gradual, 1 to 2 per 50.	Smooth to obscurely undulated.	Smooth to gently wrinkled.	Slightly digitate.	None.	Symmetrical, erect.	Even.	Unipartite or bipartite.
B. ovatus var. *baresi* Reeside.	Small, to 30 mm.	Oblong to ovate.	Gradual, 1 to 3 per 50.	Smooth to obscurely undulated.	Smooth or gently wrinkled.	Somewhat more dissected than in *B. ovatus*.	None.	Symmetrical, slightly inclined.	Lower.	Tripartite.
B. pseudovatus Elias, n. sp.	Moderate to large, to 75 mm.	Elliptical.	Gradual, 1 to 2 per 50.	Smooth.	Smooth or gently wrinkled.	Moderately dissected.	Long.	Antisiphonal side reduced, erect.	Much lower.	Bipartite.
B. pseudovatus var. *A*, Elias, n. var.	Moderate, to 40 mm.	Elliptical to ovate.	Gradual, 1 to 2 per 50.	Smooth.	Smooth.	Moderately dissected.	Short.	Nearly symmetrical, nearly erect.	Much lower.	Unipartite with tendency to tripartite.
B. compressus Say em. Meek.	Moderate to large, to 50 mm. (possibly to 75 mm.).	Oblong-ovate, subtrigonal in later stages (Meek).	Moderate to rapid (particularly in the young—Meek) 2 to 5 per 50.	Smooth, extra large shells broadly undulated (Meek).	Smooth or gently wrinkled (3 to 4 wrinkles per 10 mm.	Much dissected.	Long.	Symmetrical, erect.	Lower...	Bipartite.
B. compressus var. *recisdei* Elias, n. var.	Moderate to 50 mm.	Elongately pyriform.	Moderate to rapid, 3 to 5 per 50.	Smooth.	Wrinkled, 2 wrinkles per 10 mm.	Moderately dissected.	Long.	Antisiphonal side reduced, erect.	Lower.	Tripartite.
B. compressus var. *corrugatus* Elias, n. var.	Moderate to large, to 70 mm.	Oblong to subtrigonal.	Moderate, 2 per 50.	Smooth.	Prominently corrugated, 1 wrinkle per 10 mm.	Moderately to much dissected.	Long.	Symmetrical, inclined.	Slightly lower.	Tri- to five-partite.
B. [illegible] Elias, n. sp.	Moderate, to 50 mm.	Oblong to elliptical.	Moderate to rapid, 3 to 4 per 50.	Smooth.	Smooth.	Moderately dissected.	None.	Symmetrical, inclined.	Lower.	Unipartite.
B. [illegible] Hall and Meek.	Large to very large, to 100 mm.	Ovate to subcordiform.	Gradual, 1 per 50.	Broadly undulated, smooth in early stages.	Smooth.	Slightly dissected.	None.	Erect, nearly symmetrical.	Lower.	Unipartite to irregularly digitate.
B. [illegible] Meek.	Small, to 30 mm.	Elliptical.	Gradual, 1 per 50.	Round nodes near antisiphonal side.	Numerous gentle wrinkles.	Moderately dissected.	None.	Nearly symmetrical, erect.	Even or slightly lower.	Unipartite.
B. [illegible] Elias, n. sp.	Small, to 30 mm.	Elliptical.	Moderate 3 per 50.	Oblique ridges.	Smooth.	Septa unknown.				

or quinquepartite) seem to be of diagnostic importance, while the shape and digitation of the lateral tripartite branches of the siphonal lobe, between which the siphonal saddle is developed, have been found fairly constant in the species of *Baculites* here described and were not found of use for specific distinction of the species and varieties studied by the writer.

Among the other features of the suture the presence or absence of a stem-like body (*a*) supporting the two parallel, slender and digitate terminal branches of the first lateral lobe has been considered a very important distinguishing character between *B. compressus* and *B. ovatus* by Meek and Reeside, which is wholly shared by the writer.

Another feature of the suture, which is used for specific distinction by the writer, is the shape of the second lateral lobe and its orientation in relation to the rest of the lobes and saddles which are always fairly parallel to each other. The second lobe in some species or varieties is distinctly inclined, with its apex toward the siphonal side. When not inclined the second lobe is symmetrical in some species while in others it is much reduced on the antisiphonal side, as if crowded by the development of the antisiphonal saddle.

Baculites ovatus Say

(Plate XXXIII, figs. 3a, b, c)

1820. *Baculites ovata* Say, Am. Jour. Sci., 1 ser., vol. 2, p. 41.

1828. *B. ovata* Morton, Jour. Acad. Nat. Sci. Phila., 1 ser., vol. 6, p. 89, pl. 5, figs. 5, 6.

1830. *B. ovatus* Morton, Am. Jour. Sci., 1 ser., vol. 17, p. 280; vol. 18, p. 249, pl. 1, figs. 6-8.

1830. *B. ovatus* Morton, Acad. Nat. Sci. Phila. Jour., 1 ser., vol. 6, p. 196, pl. 8, figs. 6-8.

1834. *B. ovatus* Morton, Synopsis of organic remains of the Cretaceous group in U. S. A., p. 42, pl. 1, figs. 6-8.

1853. *B. ovatus* Marcou, Explanatory text to geologic map of United States and British provinces of North America, p. 46, pl. 7, fig. 5.

1856. *B. ovatus* Hall and Meek, Am. Acad. Arts and Sci., Mem., new ser., vol. 5, p. 399, pl. 5, figs. 1a-c; pl. 6, figs. 1-7.

1875. *B. ovatus* White, U. S. Geol. Survey, W. 100th Mer. Rept., vol. 4, p. 199, pl. 19, figs. 4a-5a-c (not figs. 4-b-c).

1876. *B. ovatus* Meek, U. S. Geol. Survey, Terr. Rept., vol. 9, p. 394, pl. 20, figs. 1a-b, 2a-d.

1889. *B. ovatus* Whiteaves, Contr. Can. Pal., vol. 1, p. 181.

1892. *B. ovatus* Whitfield, U. S. Geol. Survey, Mon. 18, p. 275, pl. 46, figs. 3-9.

1907. *B. ovatus* Weller, New Jersey Geol. Survey, Pal., vol. 4, p. 821, pl. 109, fig. 5.

1910. *B. ovatus* Grabau and Shimer, North American Index Fossils, p. 181, figs. 1437, 1438.

1916. *B. ovatus* Gardner, Maryland Geol. Survey, Upper Cretaceous, pp. 375-377, pl. 12, figs. 2, 3.

1917. *B. ovatus* Dowling, Can. Geol. Surv., Mem. 95, p. 31, figs. 2, 2a.

1926. *B. ovatus* Wade, U. S. Geol. Survey, Prof. Paper 137, p. 181, pl. 60, fig. 9.

1927. *B. ovatus* Reeside, U. S. Geol. Survey, Prof. Paper 151, p. 9, pl. 5, figs. 12, 13; pl. 6, figs. 1-4; pl. 7, figs. 1-8.

The species may be recognized by its ovate to elliptical cross section; smooth or, in the latest stages, obscurely undulated flanks; moderately large size; relatively simple, little incised suture. It differs from *B. compressus* Say in its ovate cross section and much less digitate suture.

This species, though widespread elsewhere, has not been found as yet in Kansas,[5] and only a few specimens of *B. ovatus* var. *haresi* Reeside were collected by the writer in Wallace county. According to Reeside *B. ovatus* is found in the Eagle and Telegraph Creek formations of Montana and Wyoming, in the lower half of the Pierre shale of the western Black Hills region and in equivalent formations of the midwestern states; also "in the later parts of the Montana group up to the base of the Fox Hills sandstone, and in the later Cretaceous formations of the Atlantic and Gulf Coastal Plain."[6] Meek believed that the species "ranges all through the Fort Pierre group, and up into the Fox Hills beds of the Upper Missouri Cretaceous series."[7]

The writer considers it quite possible that with separation of *B. ovatus* in the restricted sense from the somewhat similar *B. pseudovatus* and *B. clinolobatus*, the stratigraphic distribution of *B. ovatus* will be reduced and will possibly be limited to the lowermost portion of the Pierre, to the Telegraph Creek and Eagle formations and to their equivalents. The specimens of undoubted *B. ovatus*, illustrated by Reeside, came from 1,400 feet below the top of the Steele shale of Wyoming (pl. V, figs. 12, 13) and from the Eagle sandstone of Montana (pl. VII, figs. 3-5).[8]

Baculites ovatus var. *haresi* Reeside

(Plate XXXV, figs. 3a, b, 4a, b)

1927. *Baculites ovatus* Say var. *haresi* Reeside. U. S. Geol. Survey, Prof. Paper 151, p. 10, pl. 6, figs. 5-10; pl. 7, figs. 9, 10.

According to Reeside the shell is smooth with dorsum and venter rounded, and it has a relatively simple suture of the *B. ovatus* type. It differs from *B. ovatus* in possessing a compressed shell. In cross section it differs from *B. compressus* "in lacking the tendency to taper toward the siphonal side and in the details of the suture"

5. *B. ovatus* was recorded in the Pierre of Kansas by Logan (1897, pp. 222, 230-231, and 1898, p. 509), but inasmuch as this record was made at a time when the clear conception of the characteristics of the species was not established, and since no description or figures of the Kansas form is given, the validity of the record may be questioned. There are no specimens of *B. ovatus* in the old collections from western Kansas at the University.

6. Reeside, 1927, p. 10.

7. Meek, 1876, p. 397.

8. Both illustrated by Reeside, 1927.

(Reeside, 1927, p. 10). The specimens from Wallace county, which are here referred to the variety *haresi*, have the shell smooth on all sides and with a cross section of the *haresi* type (Pl. XXXV, fig. 4b). The suture of Kansas specimens has slightly more dissected lateral sinuses, but the lobes are designed in much the same fashion as in *haresi* from Wyoming (Pl. XXXV, fig. 3a). Though the dissected sinuses of Kansas specimens somewhat resemble the corresponding parts of the *compressus* type of suture, the terminal of the first lateral lobe is decidedly unlike that in *B. compressus*, but like that in *B. ovatus* and its variety *haresi*. The second lateral lobe is somewhat inclined in both the Wyoming and Kansas specimens.

Occurrence. Upper part of the Upper Weskan shale member and base of the Lake Creek shale member in sec. 15, T. 12 S., R. 38 W., Wallace county, Kansas.

According to Reeside, in the Telegraph Creek and Eagle sandstone formations of Montana and Wyoming; in the lower part of the Pierre shale on the western and northern rim of the Black Hills; in the Steele shale of Wyoming and the upper part of the Mancos shale in Utah and New Mexico.[9]

Baculites compressus Say

1820. *Baculites compressa* Say, Am. Jour. Sci., 1 ser., vol. 2, pp. 41, 42.

Not 1833. *Baculites compressa* Morton, Am. Jour. Sci., 1 ser., vol. 23, p. 291; vol. 24, pl. 9, fig. 1.

Not 1834. *Baculites compressus* Morton, Synopsis of the organic remains of the Cretaceous group in the United States, p. 43, pl. 9, fig. 1.

Not 1892. *Baculites compressus* Whitfield, U. S. Geol. Survey, Mon. 18, p. 277, pl. 46, figs. 1, 2.

For revision of the conception of the *compressus* species we are indebted to J. B. Reeside, Jr., whose opinion that Morton and Whitfield described under the name *compressus* a variety of *B. ovatus* is wholly shared by the writer. Since the type specimen, which was inadequately described and never figured by Say, is apparently lost, it is logical to accept Meek's clear characterization of the species, as suggested by Reeside, because the material which Meek collected and described came in part "from the region where Say's specimen was obtained." Morton's specimen, which was erroneously supposed to be the type of Say's species, and which was redescribed and refigured by Whitfield, has septa much like those of *B. ovatus* and can be justly classified with *B. ovatus* var. *haresi* Reeside, as proposed by Reeside. For a complete discussion of *B. compressus* of earlier authors see Reeside, 1927 (pp. 10, 11).

9. Reeside, 1927, p. 10.

Though the writer agrees that the specimen described and figured by Reeside and referred to *B. compressus* is similar in cross section and characters of the sutures with *B. compressus* as illustrated and described by Meek, there are some differences between Meek's and Reeside's specimens which may justify the separation of the latter as a variety of *B. compressus* Meek. This conclusion was reached by the writer after comparative study of numerous specimens of *B. compressus* from Wallace county, among which both the specimens comparable to Meek's and to Reeside's forms were recognized. The two forms were found in somewhat different horizons of the Pierre and thus proved to be of at least local stratigraphic value. The writer proposes to consider the form described by Meek as *Baculites compressus* s. s., and the form described by Reeside as the type of *B. compressus* var. *reesidei*.

Baculites compressus Say, Meek, s. s.

(Plate XXVIII, fig. 4; Plate XXXII, figs. 3a, b, 4a, b, c, 5a, b)

1854. *Baculites compressus* Hall and Meek, Am. Acad. Arts and Sci., Mem., new ser., vol. 5, pp. 400-402, pl. 5, figs. 2a, b; pl. 6, figs. 8, 9.

1876. *Baculites compressus* Meek, U. S. Geol. Survey, Terr. Rept., vol. 9, pp. 400-404, pl. 20, figs. 30a-c; text figs. 55, 56.

"Shell attaining a large size, rather rapidly tapering, particularly in the young, or near the smaller extremity of adult specimens, strongly compressed laterally in medium-sized examples, but more convex in the young and toward the larger extremity of large adults; nonseptate portion of fully developed specimens provided with large broad lateral undulations; lines of growth generally obscure; siphonal margin sometimes crossed by small undefined wrinkles; transverse section, like the outline of the aperture, varying with size and age, being ovate in very small specimens, strongly compressed in medium sized examples and proportionately more broadly ovate in the large adult.

"Septa usually crowded, and with lobes and sinuses deeply divided into slender branches; siphonal lobe nearly twice as wide as long and provided with two widely separated tripartite and digitate terminal branches and one smaller digitate lateral branch on each side; first lateral sinus as long as the siphonal lobe, but not much more than half as wide and very deeply divided at the end into two equal tripartite and digitate branches, with spreading subdivisions; first lateral lobe longer than the siphonal lobe, and about half as wide, with two small, parallel, sharply digitate terminal branches, standing, as it were, on a stem formed by the very narrow body which also supports on each side two opposite, sharply digitate lateral branches, one pair of which shows more or less tendency to tripart division; second lateral sinus usually a little longer, but otherwise very similar to the first; second lateral lobe shorter and broader than the first, and provided with two equal tripartite and digitate, spreading terminal branches, with much smaller, irregular, lateral branchlets; third lateral sinus usually not larger than one of the main terminal branches of the others, and deeply bifurcated at the end, the divisions

being more or less subdivided, or merely digitate; antisiphonal lobe generally only about half as long as the second lateral, and much narrower, with two to four very small lateral branches, or mere digitations on each side, and one small, tridentate, terminal division."[10]

In his material from Wallace county the writer has observed some specimens which are identical in every respect with the specimens of *B. compressus* as illustrated and described by Meek, and which, in some minor respects, differ from the more numerous specimens which he proposes to separate under the name *B. compressus* var. *reesidei*. The suture of *B. compressus* in a strict sense differs from the suture of *reesidei* in the following way:

1. The median saddle of the siphonal saddle is divided into two slightly dentate saddles *b-b* by a very short but sharp wedge-like siphonal lobe, while the corresponding small median saddle of B. *compressus* var. *reesidei* is tripartite.

2. The second lobe of *B. compressus* s. s. is wider than the second saddle and about as symmetrical as the latter, while the second lobe of var. *reesidei* is always asymmetrical with reduced branches on the antisiphonal side.

The specimens (Pl. XXVIII, fig. 4, and Pl. XXXII, figs. 4a, 4b, 4c, 5a, 5b) of the collection from Wallace county can be referred to *B. compressus* without much doubt. Their sutures are decidedly of the *B. compressus* s. s. type, being deeply digitate and having broad and symmetrical second lobes. The small median saddle (*b*) of the siphonal lobe is bipartite. The cross section of the younger of the Wallace county specimens (Pl. XXXII, fig. 4c) is about the same size and is as much compressed as Meek's type (Pl. XXXII, fig. 3b), though there is a slight, but hardly important, difference in the shape of the cross sections, the widest part of the Wallace county specimen being about in the middle of the cross section. The specimen has a very gentle but distinct and regular plication of the siphonal edge, a feature in agreement with Meek's note that the siphonal margin is "sometimes crossed by small undefined wrinkles." The regular plication of the siphonal edge of our specimens is certainly very gentle and wrinkles are quite small, the distance from one depression to another being 2 to 3 mm.

The largest Wallace county specimen is a fragment incomplete on the siphonal side (Pl. XXXII, fig. 5b). The antisiphonal side of this specimen is abruptly rounded, much like the cross section of the medium-sized *B. compressus*, as shown in text figure 55 on page 403 of Meek's monograph (Meek, 1876). Meek observed strong

10. Meek, 1876, pp. 400, 401.

lateral undulations on the nonseptate part of a large specimen of *B. compressus* (Meek, 1876, text figure 56, p. 403), but the nonseptate portion of large *B. compressus* s. s. was not collected in the Pierre of Wallace county.

Occurrence. Upper part of the Upper Weskan shale, and through the Lake Creek shale member except the top of it where the form becomes scarce or is, possibly, absent. According to Meek, in the Pierre exposed at the Great Bend of Missouri river below Fort Pierre and from "higher positions in the same formation" on Sage creek, at the Bad Lands and on Cheyenne river of South Dakota (Meek, 1876, p. 403).

The specimens described by Meek were collected in the Upper Missouri exposures of the Pierre formation, where also the type of Say was found.

Baculites compressus var. *reesidei* Elias, n. var.

(Plate XXVIII, fig. 1; Plate XXXI, fig. 3; Plate XXXII, figs. 2a, b, c; Plate XXXIII, figs. 1a, b. c; 2a, b, c)

1927. *Baculites compressus* Reeside, U. S. Geol. Survey, Prof. Paper 151, pp. 10-12, pl. 9, figs. 1-5.

The specimen described and figured by Reeside has the typical compressed form of *B. compressus* and a much digitate suture with the characteristic detail of the *compressus* type: "Two small, parallel, sharply digitate, terminal branches" of the first lateral lobe "standing, as it were, on a stem formed by the very narrow body."

The differences between the suture of var. *reesidei* and that of *B. compressus* s. s. are as follows:

1. The suture of *reesidei* is all in all comparatively less digitate.

2. The second lateral lobe of *reesidei* is comparatively narrower than the corresponding lobe of *compressus* s. s., and besides is distinctly asymmetrical, being crowded by the third lateral saddle, which is less digitate on the side facing the second lobe than in *compressus* s. s.

3. The two large tripartite terminal branches of the second lateral saddle are standing on a narrow base in typical *B. compressus*, while in var. *reesidei* the supporting base is several times wider.

4. The small median saddle (*b*) of *reesidei* is subdivided into three rounded branches, while the corresponding portion of the siphonal saddle of *compressus* s. s. is bipartite.

Besides the difference in suture the var. *reesidei* is differently ornamented on the siphonal edge than *B. compressus* s. s. The edge of the type, as figured by Reeside, is pronouncedly and regularly plicated, the distance between plications being 4 to 5 mm., or about 2 times larger than between the far less pronounced and smaller wrinkles of *B. compressus* s. s. of Wallace county. The plications of the siphonal edge of specimens of var. *reesidei* collected by the writer have a distance between plications of 4 to 5 mm. on the moderate-sized types.

Occurrence. Lake Creek shale member and lower part of Salt Grass shale member of the Pierre shale, Wallace county, Kansas. The specimen illustrated by Reeside (1927, Pl. 9, figs. 1-5) and reproduced here (Pl. XXXII, fig. 2) came from the Eagle sandstone of Montana, where the form is, however, so rare that Reeside raises a question "whether these specimens really came from the zone containing the Eagle fauna, and it must be left for future experience to determine whether *B. compressus* actually does belong to the Eagle fauna or is restricted to later faunas." [11]

Baculites compressus var. *corrugatus* Elias, n. var.

(Plate XXVIII, fig. 3; Plate XXX, fig. 3; Plate XXXII, figs. 1a, b, c)

Many compressed specimens of *B. compressus* with a still more pronouncedly corrugated siphonal side than in var. *reesidei* have been collected in the upper portion of Lake Creek shale member. The pronounced wrinkles of the siphonal side are about 10 mm. apart. The typical cross section of this variety is shown on Plate XXXII, figure 1c. The suture is decidedly of the *B. compressus* type, being deeply dissected and having terminal branches of the first lateral lobe standing on the slender stem-like body (*a*). However, the suture of this variety differs from that of *B. compressus* s. s. and of var. *reesidei* in having an inclined second lateral lobe. Furthermore the small median saddle (*b*) is tripartite with a further splitting of its lateral branchlets into two. The variety *corrugatus* differs from both typical *B. compressus* and var. *reesidei* in having a very gradually tapering shell. The type of the var. *corrugatus* (Pl. XXVIII, fig. 3) was collected and presented to the writer by Mr. Joe De Tilla, of Wallace.

A long and slender specimen of *Baculites* with cross section and suture of the *compressus* (in broad sense) type was collected in an

11. Reeside, 1927, p. 12. Reeside is now convinced that the species "does not range so low" and that *B. compressus* is wholly upper Pierre form (personal notes to the writer, April, 1931).

irregular body of "Lucina limestone" at the base of the Salt Grass shale member. This specimen allows study of the change of suture with growth of the shell. Though the initial coiled portion of the shell is not preserved, a straight portion about 48 cm. long and 5 to 31 mm. wide (in the long diameter) was secured. Several stages of the suture of this specimen are shown on Plate XXXV, figures 5b, 5c, 5d, 5e. The comparison of these sutures with those of *B. compressus* s. s. and *B. compressus* var. *reesidei* and *corrugatus* shows that in this case the former or more incised (*compressus* s. s.) type of suture is ancestral to the less incised *reesidei* and *corrugatus* types.

It is interesting to recall that in the earliest stages of the straightened shell of *B. compressus,* as demonstrated by Brown (1891, p. 159), the suture develops gradually from a slightly wavy line to the complicatedly curved and dissected sutures of the later stages. This is also a generally observed fact for all Ammonoidea, which ordinarily show a gradual complication and increased dissection of the suture with the growth of the shell. Therefore, the subsequent change from a more complicated suture to a less digitate type, as now demonstrated for this variety of *B. compressus,* is an interesting case of simplification of suture within the last survivals of the genus *Baculites* of the North American Cretaceous sea. Compare, also, the return to a less dissected type of suture with the growth of the shell in *B. grandis* (p. 347 of this paper, Pl. XXXIV, figs. 4 and 5a, b).

The evidence of a later appearance of the *reesidei* type of suture as compared with the typical *B. compressus* suture, agrees with field evidence gathered in Wallace county that *reesidei* and *corrugatus* appear in somewhat higher horizons of the Pierre formation than typical *B. compressus* s. s.

Occurrence. Var. *corrugatus* is perhaps the most common *Baculites* in the upper part of the Lake Creek shale member of the Pierre shale, while it was not found in the lower half of the member or higher than at the base of the Salt Grass shale member in Wallace county.

Baculites pseudovatus Elias, n. sp.

(Plate XXIX, figs. 1a, 1b, 2; Plate XXXIII, figs. 4a, b)

Among the specimens of *Baculites* collected from the Pierre of Wallace county there are some which have a smooth ventral side and a cross section of the *B. ovatus* type, but the suture is decidedly not that of *ovatus,* being about as much dissected as the suture of *compressus.* The writer proposes to separate these forms under a new specific name, *pseudovatus.* The forms of *Baculites* which have

sutures of the *ovatus* type but a cross section approaching that of *compressus* have been separated already by Reeside and named *B. ovatus* var. *haresi*.[12] This author states that: "An examination of a large number of specimens from various horizons, preserved in the collections in the United States National Museum, showed but one specimen combining the evenly rounded form of *B. ovatus* and the suture of *B. compressus*."[13] It would be interesting to compare the suture line of this specimen with that of *B. pseudovatus* from Wallace county, where this species and its varieties are fairly common.

Description of the *pseudovatus* suture line is as follows: Sutures moderately closely spaced; lobes and saddles not as deeply subdivided as in *B. compressus* s. s., but deeper than in *B. compressus* var. *reesidei;* siphonal saddle very narrow, being only one and a half times as wide as long, while in the latter two forms it is nearly two times as wide as long. The tripartite lateral branches of the siphonal lobe are cut in nearly the same way as in *reesidei,* while the siphonal saddle is different from both *compressus* s. s. and *reesidei,* being as wide as long, or two times narrower than in the latter two; the middle incisions of the first and second saddles are sharply pointed down at the terminal, while in the latter two the corresponding incisions finger out at the terminals; the first lateral lobe is almost perfectly round in the outline, while the corresponding lobe of *B. compressus* s. s. and var. *reesidei* is ovate or egg-shaped with the sharp end pointing distad; the two terminal branches of this lobe, which in *B. compressus* are "standing, as it were, on a stem formed by the very narrow body" (*a*), are not "parallel and sharply digitate" as in *B. compressus* s. s. and var. *reesidei,* but bifurcate each. The third saddle and the antisiphonal lobe are the same as in *B. compressus* in a broad sense.

The type specimen of this form, showing distinct sutures, was found in the limestone concretions of the middle zone of the Upper Weskan shale member. It is of moderately large size, having a long diameter of 66 mm. and a short diameter 44 mm. at the end of the septate part of the internal cast.

Numerous individuals of smaller size, not exceeding 40 mm. in the long diameter of the oval, or only slightly compressed cross section and quite smooth on the outside, are very common in the middle part of the Salt Grass shale member. Unfortunately the sutures of these numerous molds, when preserved at all, are so much

12. Reeside, 1927, p. 10.
13. Ibid., p. 11.

weathered as to preclude any reliable comparison. However, in a very few cases the suture was sufficiently preserved to allow the writer to see that it is decidedly not of the *ovatus* type, but is much closer to that of *B. pseudovatus*. The nearly complete suture of the best specimen is illustrated (Pl. XXXIII, figs. 5a, b). Some differences between this suture and that of the typical *B. pseudovatus* (Pl. XXXIII, fig. 4a) can be noticed which may justify the separation of the smaller shell as a distinct variety of *B. pseudovatus*. This separation has support in the fact that the smaller shell was found stratigraphically higher than the typical *B. pseudovatus*. The smaller form is provisionally designated here as *B. pseudovatus* var. *A* (Pl. XXVIII, fig. 2, and Pl. XXXIII, figs. 5a, 5b).

Occurrence. The type specimen of *B. pseudovatus* was found in the limestone concretion bed (No. 8) of the Upper Weskan shale member. The few specimens with ovate cross section but without any suture line which were collected near the lower part of Lake Creek shale member most probably belong to this species. The form designated here as *B. pseudovatus* var. *A* is very common in the middle zone of the Salt Grass shale member, where other fossils are rare.

Intermediate forms. There are a few specimens from the Pierre of Wallace county which may be considered intermediate forms between *B. pseudovatus* and *B. compressus* var. *reesidei*. The specimen of which the suture and cross section are shown on Plate XXXI, fig. 3, and Plate XXXIII, figs. 1a, 1b, is close to *B. compressus* var. *reesidei*, but is not as compressed as the latter and has only very faint wrinkles on the siphonal side. This specimen came from the lower half of Lake Creek shale member.

The specimens of Plate XXXV, figs. 1a, 1b and 2a, 2b, resemble *B. pseudovatus* var. A, but are comparatively more compressed. The shell of both is perfectly smooth with only very faint wrinkles on the siphonal side. The suture is of intermediate type between var. A and *B. compressus* var. *reesidei*. The specimen of Plate XXXV, figs. 1a, 1b, came from the middle zone of the Salt Grass shale member, and the specimen of Plate XXXI, figs. 2a, 2b, came from the basal zone of the same member.

Baculites grandis Hall and Meek

(Plate XXXI, figs. 1a, 1b, 2a, 2b; Plate XXXIV, figs. 4, 5a, 5b, 5c)

1854. *Baculites grandis* Hall and Meek, Am. Acad. Arts & Sci., Mem., new ser., vol. 5, p. 402, pl. 7, figs. 1, 2; pl. 8, figs. 1, 2; pl. 6, fig. 10.

1876. *B. grandis* Meek, U. S. Geol. Surv. Terr., vol. 9, p. 398, pl. 33, figs. 1a-b-c.

1926. *B. grandis* Wade, U. S. Geol. Survey, Prof. Paper 137, p. 182, pl. 60, figs. 8 and 12.

This species is recognized chiefly by the outstanding large diameter of the shell (long diameter as much as 4 inches) and very broad and strongly elevated undulations (Hall and Meek, 1854). The suture of this species closely resembles that of *B. ovatus*. Hall and Meek describe the type specimen of *B. grandis* as follows:[14]

"Shell elongate; section varying from ovate to subcordiform; surface of cast marked by very broad and strongly elevated undulations, which commence at the dorsum and pass obliquely downward, increasing rapidly in size and, crossing the sides of the shell in a broad curve, terminate abruptly on the ventro-lateral region. Undulations less distinct toward the smaller extremity and finally become obsolete. Septa very deeply lobed, principal divisions scarcely divergent. Dorsal lobe three-fourths as long and twice as wide as the superior lateral lobe; terminated on each side by a narrow elongated branch, which is irregularly sinuate and digitate at the extremity. Dorsal saddle shorter and wider than the superior lateral lobe, formed by four branches, the two terminal ones much the larger and each of them bifid at the extremity by a small sinus; the whole outline more or less sinuous and the extremities digitate. Superior lateral lobe longer by one-fifth than the inferior lateral lobe, narrower than the ventral saddle, divided at its extremity by a deep sinus into two equal parts, which are simply digitate; above these are two unequal branches on each side; terminal sinus much deeper than the lateral ones. Ventral saddle longer and about as wide as the dorsal saddle, more deeply divided at its extremity by the auxiliary lobe into two, nearly equal, branches, each of which is bifid and the extremities digitate, ventral side with three and dorsal side with two auxiliary branches. Inferior lateral lobe shorter and broader than the superior lateral lobe, divided at its extremity into two, nearly equal, branches, the one on the dorsal side bifid at the tip and the other digitate, with an auxiliary branch on the ventral side. Ventral lobe as long as the auxiliary lobe of the ventral saddle, but wider at the base, digitate at its extremity.

"Angle of the apex about 5°. Length, as deduced from the measurement of fragments, by the convergence of the dorsal and ventral sides, 5½ feet or more. Longest diameter of a fragment not distorted by pressure, 3.7 inches; shorter diameter from the surface of undulations, 3.3 inches; in the depressions between the undulations, 2.95 inches.

"The species is nearly related to *B. ovatus* of Say, from which it differs in its much greater size, larger apical angle, much stronger and more extended undulations, which cross the entire lateral surface of the shell. The section is more obtusely ovate; the lobes of the septa are much deeper, narrower, and less divergent in their branches; the digitations are sharper and more directly pointed in the longitudinal direction of the shell. The auxiliary lobe of the

14. Hall and Meek, 1854, p. 402.

ventral saddle is longer in this species, while the extremities of the terminal branches are less deeply bifid than in *B. ovatus*. In this species the two terminal branches of the superior lateral lobe are simply digitate, while in *B. ovatus* they are deeply bifid, with obtuse sinuosities. Externally in its undulations on the sides, this species resembles *B. anceps* of Lamarck, but will be readily distinguished by the absence of a dorsal carina and by its much deeper lobes with less divergent divisions. A comparison of the details of the divisions of the lobes and saddles shows a constant difference in the two species."

No specimens of this species were collected in Wallace county, the Pierre shale of which represents horizons of the formation below those in which this species has been found elsewhere. However, the writer collected from the Pierre shale of Beecher Island, Colorado, some perfectly preserved internal molds of *B. grandis*, the longer diameter of which varied from 2 to 3¾ inches. The molds show strong lateral undulations of the *B. grandis* type, and they have the sutures figured on Plate XXXIV, fig. 4, of this report.

A long specimen of *B. grandis* showing the younger stages of the shell (but not the very earliest stages and the initial coil) was collected in the Pierre at the NW¼, sec. 2, T. 2 S., R. 40 W., Cheyenne county, Kansas. The changes in the cross section of the shell and in the suture line of this specimen are illustrated on Plate XXXIV, figs. 5a, 5b, 5c. The most evident and important changes are the following:

(1) The pronounced lateral undulations, which are so typical for the adult shell, do not exist at all in the younger stages, where the sides of the shell are perfectly smooth.

(2) Contrary to the above mentioned change, the siphonal side of the shell is smooth in the adults, but in the young stages there appear occasional faint to moderately strong wrinkles spaced about 4 mm. apart.

(3) The first and second saddles are more incised in younger stages of the shell. While the degree of dissection of these saddles in the adult sutures of the shell can be (and always have been) compared with that of *B. ovatus*, the degree of dissection in younger stages is comparable to that in the adult shells of *B. compressus* var. *reesidei* and var. *corrugatus*.

(4) The central incision between the two terminal branches of the first lateral lobe is shorter in comparison with these branches in earlier stages, while the next two lateral incisions of the terminal have a tendency to come closer together and build the slender stem (*a*) supporting the terminal branches, which is a very characteristic feature of the *B. compressus* type of suture.

(5) In the younger stages the second lateral lobe is inclined as in *B. clinolobatus* and *B. compressus* var. *corrugatus*.

(6) In younger stages the cross section is elliptical and much compressed, while in the adult shell it is subtrigonal to oval.

All in all the earlier stages of the shell of *B. grandis* resemble in many respects the shell of *B. compressus,* and especially *B. compressus* var. *corrugatus*. *B. grandis* has been often compared with *B. ovatus* and inasmuch as it appears later in the Upper Cretaceous than the latter form, one is tempted to surmise that *ovatus* is an ancestral form to *grandis*. However, if the form and suture of the earlier stages of *B. grandis* are regarded as suggestive of the general appearance of the ancestral form, it must be a shell of the *B. compressus* type from which *B. grandis* descended.

Occurrence. Several localities at Black Wolf Creek, Beecher Island, Yuma county, Colorado, chiefly in and about large limestone concretions at the base of the Beecher Island shale. From the same zone in Hackberry creek and tributaries to Arikaree river in northwestern part of Cheyenne county, Kansas.

B. grandis is the most typical baculite of the topmost beds of the Pierre, but originally it was arbitrarily referred to Fox Hills formation by Meek.[15] Later, however, a belief was expressed that "neither *Baculites* nor *Inoceramus* is known to occur in the Fox Hills sandstone,"[16] and this is now generally accepted. Species of *Baculites* were recorded from the "Fox Hills" formation at Cooper Creek and at Point of Rocks of Laramie Plains, Wyoming,[17] at Bighorn Mountains[18] and in eastern Colorado.[19] According to Reeside none of these are in the Fox Hills, but rather in the Upper Pierre. In the Colorado foothills Fox Hills of the older literature is mostly Pierre.[20] Recently "some of the concretions" in the zone about 1,120 feet above the base of the "Fox Hills sandstone" of Fossil Creek were noticed to be "crowded with *Baculites*."[21] If the latter identification is correct, the survival of the genus *Baculites* high into what is usually considered by field geologists as Fox Hills formation must be considered proved unless the lithological criterion which is usually employed to distinguish Fox Hills sandstone from the Pierre shale

15. Meek, 1876, pp. 338-340.
16. Stanton, 1925, p. 8.
17. Stanton, 1897, p. 141 and p. 147.
18. Stanton in Darton, 1905, p. 52.
19. Darton, 1905, p. 109.
20. Personal note by Reeside, April, 1931.
21. Mather, Gilluly and Lusk, 1928, p. 96.

is not reliable at all and some other means of recognition of the Fox Hills sediments must be adopted.

The simultaneous disappearance in the Upper Cretaceous seas of North America of *Baculites* and *Inoceramus* can be arbitrarily chosen as the end of the Pierre time, but this feature alone is only a negative characteristic for Fox Hills time. According to Reeside,[22] the genus *Sphenodiscus* is restricted to the Fox Hills and is our best marker for the formation.

Baculites clinolobatus Elias, n. sp.

(Plate XXX, figs. 1, 2; Plate XXXIV, figs. 1, 2a, 2b, 3)

1908. *Baculites anceps* var. *leopoliensis* Novak, Bull. Acad. Sci., Cracovie, 1908, p. 326, text fig., p. 331, pl. 14, fig. 10.

Among the material collected from the Pierre shale at Beecher Island, Colorado, there are several perfectly preserved specimens with smooth surface, moderately compressed oval cross section, and a very interesting suture which is different from the rest of the American baculites known to the writer. The suture line is certainly more dissected than those of *B. ovatus* and *B. grandis* and is about as digitate as that of *B. compressus* var. *reesidei*. There are, however, some important differences which do not permit the classification of the Beecher Island species with the latter variety of *B. compressus* (or with the typical *B. compressus*). Besides the smoothness of the siphonal side of the shell and the only slightly compressed oval cross section, the design of the suture is considerably different. The siphonal lobe is as wide as long. The first lateral lobe is as oval in outline as that of *B. pseudovatus* var. A, but differs considerably from both *B. pseudovatus* and *B. compressus* by having the terminal branches not standing "on a stem formed by the very narrow body," as in all these species. They are here much separated by a prominent and long incision, which cuts the lobe deeply into two large bipartite terminal branchlets. The second lobe is not parallel to the rest of the lobes and saddles, but is considerably inclined to the axis of the shell. At the same time the inclined lobe is symmetrical in itself, having the branches of each side of equal size and sequence.

It is interesting to note that the suture of *B. clinolobatus* is more similar to one of the European types than to any one of the American species so far described. On Plate XXXIV, fig. 3, the suture line of *Baculites anceps* var. *leopoliensis* Novak is shown for comparison

22. Unpublished stratigraphic chart of Upper Cretaceous, 1930.

with the Beecher Island species. The striking similarity of the following features in the suture line of the American and European species may be noted: (1) General character and degree of dissection; (2) vertically elongated terminal branches of both the first and second lateral saddle; (3) perfectly oval outline of the first lateral lobes, which besides are dissected in the very same fashion; (4) inclination of the second lobes, the dissection of which is again very similar; (5) small, bipartite and not digitate median saddle (*b*) of the siphonal saddle.

Taking into account the character and the degree of variability of the sutures within the same individual, as exhibited in our specimen from Beecher Island (compare the two neighboring sutures of Plate XXXIV, figs. 1 and 2a), one comes to the conclusion that there is not the slightest difference between the sutures of the American and the European forms. If we add to this the similarities of the size, outline and smoothness of the septate portions of the shells, we have to confess that the two are as identical as two individuals of the same species can ever be expected to be, and therefore they should be classified under the same specific name. The writer, however, hesitates to apply to the American specimen the name *Baculites anceps* var. *leopoliensis,* because the other sutures of the same varieties, as shown on figures 5 to 9, page 331, of Novak's paper,[23] are quite different from that of figure 10, page 331, of the same paper, which is compared here with the suture of the Beecher Island form. These other sutures of the var. *leopoliensis* Novak are much like the sutures of *Baculites grandis* or *B. ovatus,* and one may question the identity of these with the specimen the suture of which is shown on figure 10, page 331, of Novak's paper, unless extreme variability of the septa of var. *leopoliensis* is admitted. The much confused situation in regard to the conception of the European species *anceps* has been pointed out by Meek, who judged "from published figures and descriptions . . . that shells belonging to more than one species have been included under Lamarck's name."[24] The situation concerning the limits of *anceps* has not improved appreciably since Meek's time, and recently again it has been pointed out that there is "a considerable variation in the concept of the species held by European students."[25]

It is advisable, therefore, to give the American forms, which are

23. Novak, 1908.
24. Meek, 1876, p. 407.
25. Reeside, 1927, p. 12.

related and in part apparently identical with some specimens referred to *B. anceps* by European authors, separate specific names, as was done in a similar case by Reeside.[26] At the same time the relation and even identity of the American forms with this or that particular European form described under the name *B. anceps* must be pointed out.

Distribution. Topmost Pierre or transitional to Fox Hills beds of shale exposed at Black Wolf Creek, near Beecher Island, Yuma county, Colorado. Also probably from the same zone of the Pierre in Cheyenne county, Kansas. The perfect molds of *Baculites* from this county in the old collection of the Geology Department of the University of Kansas are labeled *B. anceps.* They are indistinguishable from *B. clinolobatus* of Beecher Island.

Baculites meeki Elias, n. sp.

(Plate XXX, figs. 4a, 4b)

1876. *Baculites asper*? Meek, Rept. Invert. Cret. and Tert. Fossils, U. S. Geol. Survey, Terr., vol. 9, p. 404, pl. 39, figs. 10b, 10c (not figs. 10a, 10d).

Meek described two small fragments of internal molds which he doubtfully referred to *B. asper* and thought to have the same stratigraphic position "near the top of the Fox Hills group of the Upper Missouri Cretaceous series."[27] Recently Reeside, who described a much better *B. asper* from Montana and other midwestern states, correctly admitted to this species only that specimen of Meek which was illustrated on Plate 39, figures 10a, d.[28] That the two fragments belong probably to two different species was realized by Meek himself. Speaking of the fragment shown in figures 10b and c, he says, "I can scarcely doubt now that it represents a distinct species, its strong, oblique, nearly straight ridges or undulations extending entirely across the sides being a very marked feature, contrasting strongly with the nodelike prominence on the other specimen represented by figures 10a, d."[29] A fragment of the same size, cross section and sculpture (Pl. XXX, figs. 4a, 4b) was collected by the writer in the Pierre shale at Beecher Island. This checks to some extent the stratigraphic position of this rare and interesting form high in the section of the Upper Cretaceous and makes it worthy of designation by a separate name.

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26. Ibid., p. 12, *Baculites aquilansis* and its varieties.
27. Meek, 1876, p. 405.
28. Reeside, 1927, p. 13.
29. Meek, 1876, p. 405.

The names *asperoides* or *asperiformis,* proposed by Meek (1876, p. 405), were intended for the specimen 10a, d in case it was proved not to belong to *B. asper,* and, therefore, it is preferable not to use these for Meek's specimen, figures 10b, c. Therefore, the new name *meeki* is proposed for the latter and for the specimen from Beecher Island with which it is identical. The suture of *B. meeki* remains unknown.

Meek's specimen 10a, d, which is a true *B. asper,* possibly did not come from the Fox Hills formation at all, as, according to the new data, the species appears to be restricted to the lower part of the Pierre and to related formations.

Occurrence. In Beecher Island shale member, Yuma county, Colorado. According to Meek, near the top of the Fox Hills in South Dakota.

SUBFAMILY TURRILITINÆ

Genus HETEROCERAS d'Orbigny

Heteroceras tortum Meek and Hayden

(Plate XLII, fig. 2)

1858. *Helicoperas tortum,* Meek and Hayden, Proc. Acad. Nat. Sci. Phila., vol. 10, p. 54.
1864. *Heteroceras tortum,* Meek, Smithsonian Check-List N. Am. Cret. Fossils, p. 25.
1876. *Heteroceras tortum,* Meek, U. S. Geol. Survey Terr. Rept., vol. 9, p. 481, pl. 22, figs. 4a, b, c.

The writer has little doubt that a fragmentary specimen collected from Wallace county belongs to this species of Meek and Hayden. The size of the shell, the number and prominence of transverse ribs, the presence of one or possibly of two rows of not prominent nodes and the wide umbilicus are much like the features of the type described and figured by Meek.[30] The nodes are spaced as widely as in Meek's type, every second or every third rib provided with a node. Only very incomplete sutures can be observed in some portions of the Wallace county specimen.

Distribution. Meek refers this type to the "lower part of the Fort Pierre group."[31] The Wallace county specimen came also from the basal portion of the Pierre as there represented; from the top of the Sharon Springs shale member, where it was found in a limestone lens. According to Reeside "this type of shell does not occur in lower Pierre."[32]

30. Meek, 1876, p. 481, pl. 22, figs. 4a, b, c.
31. Meek, 1876, p. 482.
32. Personal note to the writer of April, 1931.

FAMILY COSMOCERATIDÆ

SUBFAMILY SCAPHITINÆ

Genus SCAPHITES Parkinson

Scaphites plenus Meek

(Plate XXXVI, figs. 1a, 1b, 1c, 2a, 2b, 2c; Plate XXXVII, figs. 1a, 1b, 1c; Plate XXXIX, figs. 1a, 1b, 1c; Plate XL, figs. 3, 4, 5, 6)

1860. *Scaphites nodosus* var. *plenus*, Meek and Hayden, Proc. Acad. Nat. Sci. Phila., p. 420.

1876. *Scaphites nodosus* var. *plenus* Meek, U. S. Geol. Survey Terr. Rept., vol. 9, p. 429, pl. 26, figs. 1a, b, c.

1885. *Scaphites subglobosus* Whiteaves, pars., Geol. Survey Canada, Contr. Can. Paleontology, vol. 1, p. 52, pl. 8, figs. 2, 2a. (Not pl. 7, fig. 3; pl. 8, figs. 1, 1a.)

1905. *Scaphites nodosus* var. *plenus*, Smith (W. D.), Jour. Geol., vol. 13, pp. 638, 644, 647-648; fig. 1 (p. 641) and figs 3-7, 8, 10 (p. 645).

1917. *Scaphites subglobosus* Dowling, pars., Geol. Survey Canada, Mem. 93, p. 32, pl. 31, figs. 2, 2a. (Not pl. 31, figs. 1, 1a. Reprints of Whiteaves' drawings.)

1927. *Acanthoscaphites nodosus* var. *plenus*, Reeside, U. S. Geol. Survey Prof. Paper 150-B, p. 32.

The following is the complete quotation of Meek's description of this interesting form: [33]

"This form differs from the typical *Scaphites nodosus*, not only in its proportionally shorter deflected body-part, but also in its much more gibbous form, and in the smaller size of its inner rows of lateral nodes, which are placed nearer the umbilical side. It also sometimes shows a slight tendency to develop a third intermediate series of very small lateral nodes about midway between the other rows, such as I have not seen in any of the other varieties.

"This tendency, however, is only manifested by a scarcely perceptible swelling of the costæ at this point, and consequently escaped the attention of the artist in drawing the figures; while even this faint tendency is not constant.

"Compared with the foregoing forms regarded as varieties of *S. nodosus*, this shell also presents a remarkable contrast, both in form and size. So great, indeed, is the difference that it seems difficult to believe that it can be properly regarded as even a marked variety of the same species as that represented by our figures 2, a, b, of plate 25; and, although I continue here to range it provisionally as a variety of *s. nodosus*, I am not altogether free from doubts on this point. Still, when we come to compare it with Owen's figure of the typical *s. nodosus*, and with the intermediate forms represented on our plate 25, little is found to distinguish it from the same, excepting its very ventricose form, a character not alone generally reliable for distinguishing species in this and allied groups of shells. Its septa will be observed to agree almost exactly, excepting in mere minute individual details, with those of the variety *brevis*, figured on plate 25, and to present the same differences in the smaller lobes from the variety *quadrangularis*, that the variety *brevis* does. At one time I was rather inclined to think that this great difference in the convexity of these shells might be merely sexual; but the fact that the variety or species *plenus* was only found at a locality on Yellowstone river (where it occurs associated

33. Meek, 1876, pp. 429, 430.

with some of the more compressed forms), while no specimens of it were found at numerous other localities where the latter forms are common, does not seem to sustain this view."

The specimen from Wallace county illustrated here (Pl. XXXVI, figs. 2a, 2b, 2c) has been (and still is) compared by the writer with the smaller specimens of *s. subglobosus* Whiteaves. At the same time he came to a conclusion that the larger specimen of Whiteaves' should not be classified with the smaller ones and that Whiteaves was in error in doing so. Inasmuch as the species established by Whiteaves was compared by Stanton [34] with *S. mullananus* Meek and Hayden, the writer felt justified in restricting the name *subglobosus* to the smaller specimens (Pl. 8, figs. 2, 2a) of Whiteaves, which certainly do not resemble *mullananus*. Consequently, he felt justified to identify the specimen from Wallace county with the smaller specimens of *S. subglobosus*. However, in discussing the matter with J. B. Reeside, the latter has advised the writer that he "examined the younger stages of *nodosus* var. *plenus* and found them to duplicate Whiteaves' figures of the supposed young of *subglobosus*." To this he added his opinion, which confirms the writer's view, that "Whiteaves was in error in supposing his small specimens to be the young of his larger specimens."[35] Subsequently Reeside has very obligingly supplied the writer with a squeeze of the inner whorl of a large specimen that agrees exactly with *subglobosus*, a cast of the holotype of *S. nodosus* var. *plenus* M. and H. and two younger individuals of the latter form from South Dakota. The examination of this material convinces the writer of the correctness of Reeside's view that both the smaller specimens of Whiteaves and the specimen from Wallace county represent younger individuals of *S. plenus*. Consequently the name *subglobosus* must be restricted to the large individual of Whiteaves' species only (Whiteaves' Pl. 7, fig. 3, and Pl. 8, figs. 1, 1a), and not to one small individual described by Whiteaves under one name, *subglobosus*.

Inasmuch as Meek illustrated only one large adult specimen of *plenus*, in which the inner volutions are hidden inside of the outer whorl, it is appropriate to illustrate and describe here the younger stages of the shell, which seem to be found more often in the Pierre shale than the complete large specimens with their living chamber preserved.

One of the most important results of the study of these earlier stages of *plenus* is the disclosed fact that the shell is wider than

34. Stanton, 1893, p. 189.

35. Letter to the writer, November 13, 1930.

high in all stages of growth. In this respect *plenus* differs considerably from all varieties of *Acanthoscaphites nodosus* (including the typical form), the shell of which is always higher than wide. This difference alone justifies the removal of *plenus* from *Acanthoscaphites nodosus*, a variety of which, though not without hesitation, it was considered by Meek.

The Wallace county specimen (Pl. XXXVI, figs. 2a, 2b, 2c) is round and much inflated; the maximum width is 20 mm.; the larger diameter is 35 mm. Volutions are broadly rounded on the periphery and on the lateral side, but are much more narrowly convex on the inner or umbilical side. The preserved nonseptate portion of the shell equals about one-third of a volution. Ribs are prominent, slightly curved toward aperture on the sides of shell and nearly or quite straight on the periphery. The ribs increase in number from the umbilicus to the periphery by intercalation of additional ones. two extra ribs being usually well developed at the row of peripheral nodes. On the rounded ventral portion of the shell, between the two rows of the peripheral nodes, an extra rib is added at each node, which brings the total number of ribs on the venter to about 34 on the half of the outer volution, as against 9 at the corresponding part of the shell of the umbilicus. The nodes occur in one row only on each side and are moderately prominent, every third, or rarely every second, of the lateral ribs being provided with a node. Inner volutions are also provided with the peripheral rows of nodes which begin to appear when the radius of volutions reaches about 5 mm.

The smallest specimens described as *S. subglobosus* by Whiteaves[36] resemble in every respect the above-described specimen from Wallace county. The ribs of Whiteaves' specimen are as much curved and nearly as densely spaced as on the Kansas specimen. However, in the latter shell there are three to four times as many ribs at the periphery as at the umbilicus, whereas Whiteaves observed "twice or perhaps three times as many on the center of the periphery as on the umbilical margin . . . in half-grown and very young shells" of the Canadian material. However, the direct comparison of our shell with the sketch by Whiteaves (Pl. 8, fig. 2) shows not much difference, if any, in the number of the lateral ribs. The number of ribs counted on the periphery of the same diameter for a volution is about 34 on the half-volution of this Kansas form and about 27 on the half-volution of the Canadian specimen (counted on the sketch on the left half of the outer volution. Pl. 8, fig. 2, of Whit-

36. Whiteaves, 1885, pl. 8, figs. 2, 2a.

eaves' paper). The nodes on our specimen are as prominent and as distantly spaced as in the Canadian type, in average about every fourth rib being provided with a node. The peripheral nodes are also noticed on the inner volutions of the Kansas specimen, which agrees with the characteristic given by Whiteaves, who noticed the nodes in the specimens "about two inches in their greatest diameter and in still smaller ones." All these smaller specimens of *S. subglobosus* Whiteaves must be now considered young stages of *S. plenus*.

The specimen (18907) from Pierre of the Black Hills (Pl. XXXVI, figs. 1a, 1b, 1c) is identical in almost every respect with *S. plenus* from Wallace county, but it has a somewhat smaller umbilicus and same minor differences in sutures. The larger specimen from western South Dakota (Pl. XXXVII, figs. 1a, 1b, 1c; Pl. XXXIX, figs. 1a, 1b, 1c) is somewhat more gibbous and the ribs of this shell are slightly coarser and more distantly spaced than in the other two shells above described. For instance, there are only 26 peripheral ribs to the half volution with diameter about 30 to 35 mm., while in the shell from Wallace county, which has the same diameter, there are 34 ribs. However, this difference is not very important and, when considered alone, hardly justifies separation of the western South Dakota shell as a variety of *S. plenus*. The size of the umbilicus of the form from South Dakota is comparable to that of the specimen from the Black Hills (18907).

Meek illustrated and described only the outer part of the suture of *plenus* (see Pl. XL, fig. 6). The material at hand permits study of the complete suture of this species on all three individuals (Pl. XL, figs. 3, 4 and 5) here described. The sutures of these individuals are not exactly alike, but their differences do not seem to be so important as to prevent consideration of the three as specifically identical. Possibly they may be regarded as varieties of *plenus*, but one must verify the constancy of those differences which seem sufficient for a separation of a variety on more material than that at the writer's disposal. The general design, the number of larger lobes and saddles and the character of dissection of the suture of the described specimens are fairly identical.

Meek pointed out the similarity of the sutures of *plenus* with those of *S. nodosus* var. *brevis*. Though admitting the similarities as pointed out by Meek, the writer sees the following common features in the sutures of Meek's type of *plenus* and of the shells here described which may serve for their distinction from the *nodosus* group:

(1) The general outline of the first lateral saddle is nearly square in both var. *brevis* and var. *quadrangularis* of *nodosus* group (see Pl. 25, figs. 1c, 2c, 3c, Meek, 1876). A square outline of this saddle is shown also by the type specimen of *S. nodosus*.[37] Contrary to this the first lateral saddle of *S. plenus* has an oval outline with outer branch much shorter than the larger inner branch; see the suture of the type of *S. plenus* (Pl. XL, fig. 6) and the sutures of all specimens here described (Pl. XL, figs. 3, 4 and 5).

(2) The second lateral lobe of *brevis* and *quadrangularis* is fairly symmetrical and is divided into two equal or nearly equal branches, each of which is in turn distinctly bipartite. The corresponding second lateral lobe of *S. plenus* has its outer branch always more digitate than the inner branch (see all sutures of the species here illustrated). Owing to this, the second lobe has an appearance of being subdivided into three branches (see the sutures of the specimens here described, Pl. XL, figs. 3, 4 and 5).

There seem to be no particular points of distinction between the inner part of the suture of *S. plenus* and the inner part of the suture of the specimens of *A. nodosus* of the writer's collection.[38]

Novak placed *nodosus* Owen and its varieties as established by Meek in the genus *Acanthoscaphites,* while Reeside expresses his opinion in this matter in the following way:

"Whether all the forms customarily placed in the species *nodosus* Owen belong to *Acanthoscaphites* may be doubted, but this comprehensive species needs extensive revision before much can be said of it with confidence, and in the meanwhile it may be left as Novak assigned it."[39]

The writer did not make any revision of the whole *nodosus* group, but his material on *plenus,* supplemented by the specimens sent to him by Reeside, permits him to conclude that *plenus* does not belong to *Acanthoscaphites,* but must be placed in *Holcoscaphites* Novak, which is a synonym of *Scaphites* in the proper sense. The following are the features of *plenus* which are characteristic of the latter genus:

(1) The shell is wider than high, which holds true in all stages of growth.

(2) In the young stages of the shell the outer sculpture is pre-

37. Owen, 1852, pl. 8, fig. 4a. Meek justly remarks that Owen's "figure of a septum" of *nodosus* "is evidently not drawn with sufficient completeness and accuracy of detail," but the first lateral saddle of Owen's drawing, which shows a square outline comparable to that of *brevis* and *quadrangularis,* seems to be more accurately drawn than the rest of the suture.

38. The writer does not know of any published illustrations of the inner part of the sutures of *A. nodosus* or its varieties.

39. Reeside, 1927, p. 27.

cisely of the type which is considered typical for *Scaphites:* "the ribs pass without nodes from the umbilicus, end at the edges of the venter with a nodose thickening and then split into weaker, secondary ribs."[40]

The suture of *plenus* is of the type of *S. aequalis* Sowerby except that the second lateral lobe is much shorter than the first lateral lobe, while according to Novak the lobes of *Holcoscaphites* (= *Scaphites*) decrease in size gradually. However, it must be added that in the suture which is next to the living chamber in the specimen of *S. plenus* from Wallace county (Pl. XL, fig. 5), the first lateral lobe is only slightly higher than the second lobe, while in the next suture (not illustrated here) the first lobe is much higher than the second. It seems as if the difference in the sutures of this sort may be considered of lesser importance than the differences in the shape and sculpture of the shells of *Scaphites* group. The genus *Yezoites*, based by Yabe on some peculiar characters of the internal (dorsal) part of the suture in some Japanese species, is not regarded valid either by Novak or by Reeside.

In conclusion the writer would say that inasmuch as he did not have an opportunity to revise the whole group *nodosus* Owen he leaves open to question the generic relation between *plenus* and the rest of the shells of the *nodosus* group; he thinks, however, that there is enough evidence at hand to make *plenus* a distinct species. The possibility of such separation of *S. plenus* Meek from the rest of the *nodosus* group was foreseen by Meek himself,[41] while Reeside also holds the view that "there is warrant" to do so.[42]

Occurrence. The specimen of *S. plenus* was found in the concretionary limestone zone at the base of Salt Grass shale member in Wallace county. The type specimen of *S. plenus* is referred by Meek to the "upper part of the Fort Pierre group of the Upper Missouri Cretaceous series."[43] Canadian specimens are referred to the Fox Hills sandstone north of Wood Mountain, Alberta.[44] It appears as if *S. plenus* is characteristic of somewhat higher horizons of the Pierre than *A. nodosus* and its varieties *brevis* and *quadrangularis*.

40. Reeside, 1927, p. 24, definition of genus *Holcoscaphites* (= *Scaphites*) translated after Novak.

41. Meek, 1876, pp. 429, 430.

42. Letter to the writer of December 9, 1930.

43. Meek, 1876, p. 430.

44. Ann. Rept. Geol. Survey Canada, vol. 1, p. 46 C, also Dowling, 1917, p. 32. According to Reeside this "Fox Hills" is not true Fox Hills, but a sandy Pierre horizon (personal note of April, 1931).

Genus ACANTHOSCAPHITES Novak

Acanthoscaphites nodosus (Owen) (1852)

This species of Owen and its varieties *brevis* and *quadrangularis* established by Meek are the most common scaphites of the Pierre in Kansas. However, complete and undistorted specimens of this form are very rare and, in nearly every case, the species or its varieties were identified on fragments of various size. In spite of the fragmentary occurrence, this important index fossil of the Pierre can be nearly always identified with a fair degree of accuracy, its comparatively large size, coarseness of costæ and prominence of nodes being very characteristic.

Acanthoscaphites nodosus (Owen) s. s.

(Plate XXXVIII, figs. 1a, 1b, 2, 3)

1852. *Scaphites* (*Ammonites*) *nodosus*, Owen, Report Geol. Survey Iowa, Wis. and Minn., p. 581, pl. 8, fig. 4.

1892. *Scaphites nodosus*, Whitfield, U. S. Geol. Survey, Mem. 18, p. 261, pl. 44, figs. 13, 14.

1896. *Scaphites nodosus*, Gilbert, U. S. Geol. Survey, 17th Ann. Rept., pt. 2, pl. 65, fig. 2.

1905. *Scaphites nodosus* Owen, Smith (W. D.), Jour. Geol., vol. 13, pp. 638, 648.

1907. *Scaphites nodosus* Owen, Weller, Rept. Cret. Pal. New Jersey, Geol. Surv. New Jersey, Pal., vol. 4, p. 824, pl. 107, figs. 1, 2.

1916. *Acanthoscaphites nodosus* (Owen), Novak, Die Bedeutung von *Scaphites* für die Gliederung der ober Kreide: K. -k. geol. Reichsanstalt Verh., Jahrg. 1916, w. 3, p. 63.

1927. *Acanthoscaphites nodosus*, Reeside, U. S. Geol. Survey, Prof. Paper, 150-B, p. 32.

Owen describes the type of the species as follows: [45]

"Shell large and ponderous. Volutions subcylindrical, enlarging gradually towards the terminal chamber. Surface ornamented with sinous costæ, most of which bifurcate at different distances from the umbilicus and, thus multiplied, proceed across the dorsum. Two rows of very prominent tubercles. The row near the periphery especially large and prominent, and from one-half to three-quarters of an inch apart. Aperture subovate. Greatest diameter, four inches; greatest thickness, two and a half inches."

The following characteristic features of the typical form as compared with its variety *brevis* and *quadrangularis* were used by the writer in identification of his material from the Pierre of Wallace county: (1) Larger size; (2) costæ of both periphery and sides are more distant than in *brevis* and *quadrangularis;* (3) both lateral nodes and peripheral nodes are equally prominent and nearly equidistantly spaced; (4) the row of nodes corresponding to the umbilical nodes of var. *brevis* and var. *quadrangularis* in the typical *nodosus* is nearly in the middle of the flank of the shell.

45. Owen, 1852, p. 581.

Occurrence. In the upper half of the Upper Weskan member and in the Lake Creek member of the Pierre shale of Wallace county. Owen's type specimen came from the upper part of the Pierre from near Cheyenne river, South Dakota.[46] The specimen figured by Gilbert came from "Tepee butte"-zone of the Pierre of Arkansas river, Colorado. According to Reeside [47] the species belongs to the upper, as compared to the lower, part of the Pierre.

Acanthoscaphites nodosus var. *brevis* Meek

(Plate XXXVI, fig. 2; Plate XLI, fig. 3)

1876. *Scaphites nodosus* var. *brevis,* Meek, U. S. Geol. Survey Terr. Rept., vol. 9, p. 426, pl. 25, figs. 1a, b, c.

Not 1905. *Scaphites nodosus* var. *brevis* Smith (W. D.), Jour. Geol., vol. 13, pp. 638, 640-649, fig. 1-2 (p. 641).

1927. *Acanthoscaphites nodosus* var. *brevis,* Reeside, U. S. Geol. Survey, Prof. Paper 150-B, p. 32.

Meek states that: [48] "This shell differs from Doctor Owen's type of his *S. nodosus* in having its nonseptate part deflected portion of the last volution much shorter, and its inner volutions more compressed, while the nodes near its umbilicus are decidely smaller."

The writer would add to this that the costæ of var. *brevis* are more closely spaced than in the typical *A. nodosus* and that the lateral row of nodes in the former is closer to the umbilicus than in the latter form: "along about one-third the height from the umbilicus" in var. *brevis.*[49] Furthermore, there are only a few (three on fig. 1b of Meek's monograph) and smaller nodes at the umbilicus of var. *brevis,* while the lateral nodes are numerous (8 or more) in the typical *A. nodosus* and at least the middle nodes of the row are not less prominent than the peripheral nodes of the species.[50]

Occurrence. In the Lake Creek member and at the base of the Salt Grass member of the Pierre shale in Wallace county; possibly also in the Upper Weskan shale member. The type of the variety came from the upper part of the Pierre on Yellowstone river, Montana.[51] In the Upper Pierre according to Reeside.[52]

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46. Meek, 1876, p. 428.
47. Reeside, 1927, p. 32.
48. Meek, 1876, p. 427.
49. Meek, 1876, p. 427.
50. Compare Owen, 1852, pl. 8, fig. 4.
51. Meek, 1876, p. 428.
52. Reeside, 1927, p. 32.

Acanthoscaphites nodosus var. *quadrangularis* Meek and Hayden

(Plate XXXVII, fig. 3)

1860. *Scaphites nodosus* var. *quadrangularis* Meek and Hayden, Proc. Acad. Nat. Sci. Phila., vol. 12, p. 420.

1860. *Scaphites nodosus* var. *exilis* Meek and Hayden, Proc. Acad. Nat. Sci. Phila., vol. 12, p. 420.

1876. *Scaphites nodosus* var. *quadrangularis,* Meek, U. S. Geol. Survey Terr., Rept., vol. 9, p. 428, pl. 25, figs. 2a, b, c; 3a, b, c and 4.

Not 1905. *Scaphites nodosus* var. *quadrangularis,* Smith (W. D.), Jour. Geol., vol. 13, pp. 638, 640-649, fig. 1-3 (p. 641).

1927. *Acanthoscaphites nodosus* var. *quadrangularis* Reeside, U. S. Geol. Survey, Prof. Paper 150-B, p. 32.

According to Meek this variety differs from var. *brevis* "not only in its usually smaller size, but also in having its periphery flattened, its umbilicus rather large, and its body part narrower in its vertical diameter, as well as less straightened along its upper margin. Its inner row of nodes will also be seen to be nearer the umbilical margin, and the outer rows near the periphery; the latter character being, of course, due to the flattening of the periphery. There will also be seen to be some slight differences in the details of its septa, particularly in the form of its third lateral lobe, and the presence of a small fourth lateral.

"Compared with Doctor Owen's typical form of *S. nodosus* it will be seen to differ even more strongly than the last, in form and several other respects."

The smaller size, the presence of a number of rather prominent nodes at the umbilicus and subquadrate cross section are the chief characters used for identification of this variety of *A. nodosus* in the Pierre of Wallace county.

Occurrence. In the Upper Weskan and in the Lake Creek shale members of Wallace county Pierre; also at the base of the Salt Grass shale member. In the upper part of the Pierre on Yellowstone river, Montana, according to Meek.[53] In the upper Pierre according to Reeside.[54]

Acanthoscaphites (?) *reesidei* Wade

1926. *Scaphites reesidei* Wade, U. S. Geol. Survey, Prof. Paper 137, p. 183, pl. 61, figs. 3-7.

1927. *Acanthoscaphites* (?) *reesidei,* Reeside, U. S. Geol. Survey, Prof. Paper 150-B, p. 33.

A good and nearly complete (except living chamber) specimen of this rare species was found by the writer in Wallace county in 1927. Unfortunately, the specimen is not now at his disposal and therefore it can be neither illustrated nor described. The specimen

53. Meek, 1876, p. 429.

54. Reeside, 1927, p. 32.

was compared by the writer in 1928 with the figures and descriptions by Wade and was found to agree with the figure of the type in every respect, including the character of the suture.

Occurrence. In limestone concretionary zone at the base of the Salt Grass shale member in Wallace county. The type specimen of *A. reesidei* came from the Coon creek locality of the Ripley formation in Tennessee.

Genus DISCOSCAPHITES Meek

cf. *Discoscaphites* (?) *constrictus* Sowerby var. *tenuistriatus* (Kner)

(Plate XXIX, fig. 3; Plate XXXIX, fig. 10)

Compare 1908. *Scaphites constrictus* Sowerby, Grossouvre, Mem. Mus. Royale D' Hist. Nat. Belgique, p. 36, pl. 11, fig. 6.

Compare 1911. *Hoploscaphites constrictus-tenuistriatus* Novak, Acad. Sci. Cracovie Bull. internat., sér. B, p. 585, pl. 33, figs. 13, 21 and 22.

Though the writer realizes that an identification of European species among the American Upper Cretaceous forms must be made with caution, he nevertheless compares provisionally fragmentary remains from Wallace county with some illustrated shells of the *constrictus* type from Europe, because the Wallace county remains differ from all American Upper Cretaceous amonities so far described. Their size is small, they are considerably compressed, their surface is marked by fine ribs and they have a small umbilicus.

In all these respects the remains are comparable to *Discoscaphites nicolleti* Morton, but not the faintest trace of tubercles of any kind can be observed on the specimens from Wallace county. It is interesting to note that Meek[55] compared *D. nicolleti* with some tuberculate varieties of *Scaphites constrictus* Sowerby from Europe, as illustrated by d'Orbigny,[56] and according to Novak both tuberculate and nontuberculate forms exist among the shells which he refers to *S. constrictus* var. *tenuistriatus*, with which the specimens from Wallace county have so much in common. Thus it appears as if we might extend the conception of *D. nicolleti* so as to include nontuberculate forms, which otherwise differ little or not at all from the typical *nicolleti*. This, however, is not advisable for the following reasons:

(1) The presence of peripheral tubercles is mentioned in the original characterization of the type specimen of *nicolleti* Morton.[57]

(2) The stratigraphic position of true *nicolleti* is Fox Hills and the upper part of the Pierre. Though the writer collected this species

55. Meek, 1876, p. 436.

56. Paléont. Fr., Terr. Cret., I, pl. 129, fig. 8.

57. 1842, p. 209, though tubercles are not shown on the much generalized sketch, pl. 10, fig. 3.

in Wallace county as low as at the top of the Salt Grass shale member, which is about in the middle of the Pierre, he considers the Salt Grass specimens a new variety of *nicolleti,* which is described below (this variety is tuberculate). The remains here compared with the nontuberculate varieties of European *constrictus* have been collected as low in the Pierre as in the Lower Weskan shale member, which is only about 200 feet above the base of the formation.

If, in the course of time, the identity of *nicolleti* with European *constrictus* is proved, there would be more reason to separate the nontuberculate European variety of *constrictus* as a distinct form, and not, contrary to this, mix up the American tuberculate and nontuberculate forms of the *nicolleti* type, which, as far as is established at present, do not occur together in the stratigraphic column of the North American Upper Cretaceous.

In view of all these considerations the nontuberculate remains here described should be given a new name. However, due to the imperfection of the remains from Wallace county and the badly preserved suture, the writer prefers to designate them temporarily as cf. *D. constrictus* var. *tenuistriatus.*

Occurrence. Two small individuals, the better of which is shown on Plate XXXIX, figure 10, came from limestone concretions of the Weskan shale, and probably from the Lower Weskan shale member. The larger individual of Plate XXIX, figure 3, was collected in the Upper Lake Creek shale member. All specimens were collected in Wallace county.

Discoscaphites nicolleti (Morton) Meek

1842. *Ammonites nicolleti* Morton, Acad. Nat. Sci. Phila, Jour., 1 ser., vol. 8, pt. 2, p. 209, pl. 10, fig. 3.

1852. *Ammonites nicolleti* Owen, Rept. U. S. Geol. Surv. Wisconsin, Iowa and Minnesota, pl. 8, fig. 1.

1852. *Scaphites (Ammonites) comprimis* Owen, ibid., p. 580, pl. 7, fig. 4.

1857. *Scaphites nicolleti* Meek and Hayden, Acad. Nat. Sci. Phila. Jour., vol. 8, p. 281.

1876. *Scaphites (Discoscaphites) nicolleti* Meek, U. S. Geol. Survey Terr., Rept., vol. 9, p. 435, pl. 34, figs. 2 and 4.

1927. *Discoscaphites nicolleti* Reeside, U. S. Geol. Survey, Prof. Paper 150-B, p. 31-32, pl. 9, figs. 5-7.

Meek gives the following definition of the species:

"Shell oval-subcircular, much compressed; volutions so deeply embracing as to leave only a small umbilicus, all strongly compressed laterally, inner ones narrowly rounded on the periphery; deflected part of last turn so very short as not to become free at the aperture, narrowly flattened on the periphery below, and somewhat widened and straightened along the upper margin near the umbilicus; aperture narrow-oval; surface ornamented by numerous small, somewhat flexuous costæ, which increase by division and intercalation so as

to number about five time as many around the periphery as at the inner side; costæ everywhere without tubercles or nodes, excepting a single row along each side of the flattened periphery of the outer volution, all crossing the periphery with a moderate forward curve.

"Length, 2.31 inches; height, 1.92 inches; convexity, about 0.62 inch."[58]

The suture of the species was unknown until the description by Meek. According to this author the suture of the species is much like that of *Scaphites conradi* var. *intermedius,* which "holds almost an exactly intermediate position, as it were, between the typical *S. conradi* and *S. nicolleti* Morton (= *S. comprimis* Owen), both in external and internal characters."[59]

Though Meek points out some minor differences in the sutures of *S. nicolleti* and *S. conradi* var. *intermedius,* he says that "these differences in the details of the lobes and sinuses of the septa are not, it must be confessed, very important, or even not greater than we may frequently see between those of different individuals of the same species."[60] Meek furthermore stresses the differences in the sculpture between the *conradi* and *nicolleti* groups and points out the "entire absence of tubercles on the sides of all the volutions, both inner and outer"[61] of the *nicolleti* form. In this respect the "shell departs from the *Discoscaphites* group," but "from its close general relations to the last, however, in which that character does occur, both in form and in the details of the septa, it seems improper to place it in any other section."[62]

It is interesting to point out that in Owen's *Scaphites comprimis,* which Meek classifies with *D. nicolleti,* there is a row of "more obscure tubercles, one-fourth of the distance from the inner margin of the convolutions,"[63] which are also shown on Owen's sketch. Since the outer sculpture is an important feature in classification of the species of the *Discoscaphites* group, it appears that Owen's type may possibly be a variety of *D. nicolleti,* having not only an additional row of tubercles but also a somewhat different arrangement of costæ. As will be shown below, the specimens of *D. nicolleti* from Wallace county have more distantly spaced marginal costæ than in the specimens described by Meek. There are again some differences in the outer sculpture as well as in the suture line, which permit the separation of this as a new variety of the *nicolleti* type.

58. Meek, 1876, p. 435.
59. Meek, 1876, p. 434.
60. Ibid., p. 434.
61. Ibid., p. 436.
62. Ibid., p. 436.
63. Owen, 1852, p. 580.

Occurrence. According to Meek the species was found in the Fox Hills group in South Dakota and Montana. The specimen illustrated by Reeside came from the top of the Pierre shale at Linton, North Dakota.

Discoscaphites nicolleti var. *saltgrassensis* Elias, n. var.

(Plate XXXVI, figs. 3a, 3b, 3c; Plate XL, fig. 1)

The variety differs from *D. nicolleti* as described by Meek in having the marginal tubercles not on every costæ as shown in Meek's monograph (Pl. 34, fig. 26).[64] On the shell of var. *saltgrassensis* the tubercles begin to appear when the radius of the volutions approaches 15 mm. At this radius each fourth of the peripheral costæ has a tubercle, but soon, at about 20 mm. radius of the volutions, each third costæ has a tubercle, while Meek shows a tubercle on every peripheral costa at 23 to 25 mm. radius.[65] The number of the costæ of the specimens as figured by Meek appears to be about the same as on the specimens from Wallace county. Meek does not give any figures for the number of the Costæ on the periphery, which for our variety is 10 to 11 per 1 cm. at the radius of 15 mm. and is about 7 per 1 cm. at the end of the next half of a complete volution or at about 25 mm. radius. The shape of the variety is the same as in the specimens figured by Meek, the periphery of the volutions being broadly rounded (as on Meek's Pl. 34, fig. 46, and not as on Pl. 34, fig. 26, where the periphery is shown to be nearly acute at the end of the preserved volutions).

The suture of the variety differs in one respect more from that of *D. nicolleti* Meek than the latter differs from the suture of *D. conradi* var. *intermedius*. The first lateral saddle of var. *saltgrassensis* is oval in outline while this saddle has a nearly square outline in both *D. nicolleti* Meek and *D. conradi* var. *intermedius* Meek. In other words, while the three branches of the first saddles in the two latter types are nearly equal in height, the central branch of the first saddle of var. *saltgrassensis* is the highest, while the lateral branches and branchlets slope down, gradually filling a perfectly oval outline of the saddle (see Pl. XL, fig. 1, of this report). However, this and some other minor differences in the suture of var. *saltgrassensis* are not very important and, if not supported by differences in the sculpture, would not justify the separation of the variety *saltgrassensis* from typical *D. nicolleti.*

64. Meek, 1876.
65. Ibid., pl. 34, fig. 26.

The lower stratigraphic position of the var. *saltgrassensis* at the middle of the Pierre formation is another point in favor of its separation as a distinct variety of *D. nicolleti,* which belongs to the Fox Hills beds and to the top of the Pierre shale.

It is interesting to add that the suture of *D. nicolleti* from the top of the Pierre at Linton, South Dakota, as figured by Reeside (1927, Pl. 9, fig. 7) is closer to that of var. *saltgrassensis* than to the typical form as shown by Meek.

Occurrence. The variety was found in a lens of typical "*Lucina* limestone" at the top of the Salt Grass member of the Pierre in Wallace county in the center of sec. 2, T. 12 S., R. 42 W.; thus stratigraphically the variety belongs to the middle of the Pierre as represented in northwestern Kansas. It appears that the first appearance of the *Discoscaphites nicolleti* in the Pierre of the Central High Plains belongs to this horizon. At the base of the Salt Grass member, or only about 50 to 60 feet stratigraphically below the beds with *D. nicolleti* var. *saltgrassensis,* the typical representatives of the *Acanthoscaphites* group, such as *A. nodosus* var. *brevis* and var. *quadrangularis* and also *Acanthoscaphites* (?) *reesidei* and *Scaphites plenus,* were collected. A small scaphite, very similar to var. *saltgrassensis,* was also collected in the "Lucina limestone" cores at the base of the Salt Grass member, but these specimens were not preserved well enough for precise identification.

Discoscaphites conradi (Morton)

(Plate XXXIX, figs. 9a, 9b)

1834. *Ammonites conradi,* Morton, Synopsis of organic remains of Cretaceous group of the U. S. A., p. 39, pl. 16, figs. 1-3.

1850. *Scaphites conradi,* d'Orbigny, Prodrôme de Paléon., p. 214.

1871. *Scaphites (Discoscaphites) conradi,* Meek, Am. Phil. So., Proc., vol. 11, p. 429.

1876. *Scaphites (Discoscaphites) conradi,* Meek, U. S. Geol. Survey Terr., Rept., vol. 9, p. 430, pl. 36, fig. 2.

1916. *Scaphites conradi,* Gardner, Maryland Geol. Survey, Upper Cretaceous, p. 383, pl. 12, fig. 1.

1927. *Discoscaphites conradi,* Reeside, U. S. Geol. Survey, Prof. Paper 150-B, p. 28.

A fragment which undoubtedly belongs to this form was found in the Beecher Island shale and identified by the writer in 1928. The species was recognized by the discoidal form and by the presence of three to four rows of nodes on the outer part of the flanks of the shell. These nodes were located on the costæ of the outer sculpture. The size of the shell as judged from the fragment is suggestive of either *D. conradi* or *D. cheyennensis* of the North American *Discoscaphites,* while the comparative evenness of the venter resembles

that of former species. Among the so-far published illustrations of American *Discoscaphites* the shell from Beecher Island resembles most that figured by Gardner.[66] Another fragment of a smaller individual of *D. conradi* was found by the writer in 1930 and is here illustrated (Pl. XXXIX, figs. 9a, 9b).

Occurrence. In the Beecher Island member of the Pierre shale at Beecher Island, Colorado. The type species of *D. conradi* came from the Upper Cretaceous beds of Alabama.[67] According to Meek: "It also occurs at the same horizon in New Jersey," [68] but no identical or related forms have been described in comprehensive monographs of the Upper Cretaceous fauna of New Jersey by later authors.[69] Stephenson records *D. conradi* in the *Exogyra costata* zone of the Eastern Gulf region and in the *Liopistha protexta* subzone at the top of Selma chalk in western Alabama and east-central Mississippi.[70]

Meek has "seen specimens of it from Saskatchewan, British America, in Professor Hind's collections." The specimens described by Meek came from the "Fox Hills group at Fox Hills, Long Lake, Moreau river and near the eastern base of the Black Hills, Dakota." [71]

Gardner described the species from the Monmouth formation of Maryland.[72] According to Reeside the species occurs in the Fox Hills sandstone, which he compares with the Mæstrichtian of Europe.

Discoscaphites abyssinus (Morton)

(Plate XXXIX, figs. 2, 3, 4, 5, 6a, 6b, 7, 8; Plate XL, fig. 2)

1841. *Ammonites abyssinus* Morton, Jour. Acad. Nat. Sci. Phila., vol. 8, p. 209, pl. 10, figure 4.

1856. *Scaphites mandanensis?* Meek and Hayden, Proc. Acad. Nat. Sci. Phila., vol. 8, p. 281.

1860. *Scaphites abyssinus* Meek and Hayden, Proc. Acad. Nat. Sci. Phila., vol. 12, p. 420.

1864. *Scaphites abyssinus* Meek and Hayden, Smithsonian Check-List of North American Cretaceous Fossils, p. 23.

1876. *Scaphites (Discoscaphites) abyssinus* Meek, Invertebrate Cretaceous and Tertiary fossils of the Upper Missouri country, U. S. Geol. Survey Terr., Rept., vol. 9, p. 441, pl. 35, figs. 2a, b and 4.

1927. *Discoscaphites abyssinus* Reeside, Scaphites, an Upper Cretaceous Ammonite group, U. S. Geol. Survey, Prof. Paper 150-B, pp. 27, 36.

66. Gardner, 1916, pl. 12.
67. Morton, 1834, p. 39.
68. Meek, 1876, p. 432.
69. Whitfield, 1886 and 1892; Weller, 1907.
70. Stephenson, 1914, pp. 36-37.
71. Meek, 1876, p. 432.
72. Gardner, 1916, p. 383, pl. 11.

Meek gives the following definition of the species: [73]

"Shell short-oval, or subcircular, much compressed; inner volutions deeply embraced within the dorsal groove of each succeeding turn; last whorl flattened on the sides and periphery, having a more or less distinct subnodose angle around the umbilicus, and on each side of the periphery; nonseptate portion short, not widened or straightened along its upper margin, and deviating so little from the regular curve of the inner whorls as to become but slightly disconnected from them at the aperture; umbilicus rather small; aperture oval or subcordate; surface ornamented by rather distinct, straight, or slightly flexuous costæ, which increase chiefly by the intercalation of shorter ones between the longer, so as to number from two to three times as many at the periphery as near the umbilicus; those on the inner whorls often supporting some three or more rows of very small nodes on each side, in addition to the larger series on each side of the narrow, flattened periphery.

"Septa divided into three or four lobes and as many sinuses on each side of the siphonal lobe, which is of an oblong form, being a little longer than wide, with two principal branches on each side, the two terminal of which are slender, larger than the others, nearly parallel, obscurely bifid, and provided with a few obtuse, short digitations or crenulations; while the lateral branches are short and spreading, the larger pair being merely obtusely tridentate, and the others simple; first lateral sinus as long as the siphonal lobe, and near one-fourth wider, with a nearly quadrangular form, and provided with two large unequal, irregular branches, with short, obtusely crenate subdivisions; first lateral lobe a little shorter than the siphonal, and of nearly the same breadth, with two branches on each side, the two terminal of which are of moderate length, spreading, bifid, and provided with obtusely crenate or dentate margins, while the two lateral branches are much smaller, directed out at right angles from the margins, and each obtusely tridentate at the end; second lateral sinus scarcely half as large as the first, and bearing two unequal, shortly bipartite or tripartite, deeply sinuous, and obtusely dentate terminal branches, and one or two unequal, short, nearly simple, lateral branchlets; second lateral lobe much like the first, but scarcely more than half as long and wide; third lateral sinus about one-third as large as the second, with two short, spreading, obtusely dentate, terminal branches; third lateral lobe very small and merely obscurely bilobate at the end; fourth lateral sinus as long as the third lateral lobe, but wider and faintly bilobate at the end; fourth lateral lobe slightly wider and longer than the third, but more distinctly trilobate at the end.

"Length, 2.09 inches; height, 1.65 inches; convexity, 0.63 inch.

"The angle around the inner side of the nonseptate part of the outer volution in this species is not always well marked, and varies a little in its distance from the umbilical margin. It is apparently always provided with a row of low prominences, like transversely-elongated nodes, that never exist on the inner volutions. The angle on each side of the narrow, flattened periphery, with its row of nodes, seems to be always well defined on the outer volution, excepting near the aperture, where both angles and nodes usually fade away and the costæ become finer and crowded. On the inner volutions, also, the

73. Meek, 1876, pp. 441, 442.

peripheral angles become obscure or obsolete, though their place is occupied by the rows of nodes reduced in size. The little nodes seen on the sides of the inner volutions, and sometimes on the inner half of the last turn, are placed on the costæ so as to form about three, nearly equidistant, revolving rows on each side of the shell."

The specimens which were collected in the Upper Pierre shale near Beecher Island and in the corresponding beds in northern part of Cheyenne county, Kansas, are somewhat smaller than the types figured by Morton and Meek and are slightly different in some other respects, which, however, do not seem to be so important as to warrant separation of the form collected from these localities from the typical species.

The fragment of Plate XXXIX, figure 8, represents the largest individual of the collection, which approaches in size Meek's types, while the nearly complete specimen (Pl. XXXIX, fig. 3) is only slightly smaller. It is interesting to note that in both these individuals the "low prominences like transversely elongated nodes" (Meek) are so insignificant as to be nearly absent. However, they are quite prominent on smaller individuals (Pl. XXXIX, figs. 2, 4, 7a). The small lateral nodes of the inner volutions seem to be absent in all specimens of the collection with the exception of one, in which only one row of lateral nodes (instead of three rows as according to Meek) is developed (Pl. XXXIX, fig. 4). However, the presence of lateral nodes is not a constant feature of the species. When comparing his material with Morton's type Meek remarked that the type specimen itself "showed none of the little nodes on the costæ of the sides of the shell" and that "these are not always present" on the material described by Meek. The suture of the form here described does not differ much from that shown by Meek for *D. abyssinus* (the suture of Morton's type is unknown). The main features which permit classification of the specimens from Beecher Island shale member with Morton's species are the general similarity in form and, to a certain extent, in size of the shells; the presence of prominent nodes on the periphery and at the umbilical margin of the outer volution; the change from rather prominent regular costæ to much finer and crowded costæ at the outer part of the aperture; the very narrow umbilicus. The suture is quite typical for the species (see Pl. XL, fig. 2).

To the characterization of the species given by Meek may be added that the living chamber, as noted on the material here described, occupies a little more than one-half of a volution.

Distribution. In the Beecher Island shale member of the Pierre in sec. 8, T. 2 S., R. 43 W., Yuma county, Colorado, and in the corresponding beds in NE¼ sec. 9, T. 2 S., R. 42 W. and in NE¼ sec. 5, T. 1 S., R. 39 W. of Cheyenne county, Kansas.

According to Meek the specimens from Moreau river, South Dakota, belong to the "Fox Hills group."

SUBFAMILY PLACENTICERATINÆ

Genus PLACENTICERAS Hyatt

Placenticeras meeki Boehm

(Plate XLI, figs. 1a, 1b, 2; Plate XLII, figs. 1a, 1b)

1876. *Placenticeras placenta,* Meek, U. S. Geol. Survey Terr., vol. 9, p. 465, text fig. 65; pl. 24, fig. 2.

1898. *Placenticeras meeki* Boehm, Deutsche Geol. Gesell. Zeitschr., vol. 50, p. 200 (footnote).

1903. *Placenticeras whitfieldi* Hyatt, U. S. Geol. Survey, Mon. 44, p. 221, pl. 45, figs. 3-16; pl. 46; pl. 47, figs. 1-4.

1910. *Placenticeras whitefieldi* Grabau and Shimer, North American Index Fossils, p. 218, figs. 1493, 1494.

1927. *Placenticeras meeki,* Reeside, U. S. Geol. Survey, Prof. Paper 151, p. 29, pl. 22, figs. 5-7; pl. 23; pl. 24; pl. 25, figs. 1-2.

This large *Placenticeras* is common in the Pierre of Wallace county, where no other species of the genus have been found by the writer. The species was recognized by its large size, smooth non-tuberculate sides, compressed volutions, venter narrow in youth and moderately rounded in old age, narrow umbilicus and a very typical suture. For the detailed characteristics of the species see Hyatt [74] and Reeside.[75]

The remains collected in Wallace county represent shells of large to very large size. A nearly complete shell (Pl. XLI, figs. 1a, 1b, 2 and Pl. XLII, figs. 1a, 1b) approaches 18 inches in diameter with part of the living chamber preserved. The living chamber shows broadly undulated venter (Pl. XLII, fig. 1a).

Some fragments from Wallace county, which seem to belong to *P. meeki,* indicate that the species attained as large a size as 3½ feet in diameter.

Occurrence. In the lower and upper Weskan shale member and in the lower part of Lake Creek shale member of the Pierre in Wallace county. According to Reeside [76] this species "has been found widely distributed in the Pierre shale and equivalent formations of the Western Interior province of the American Cretaceous."

74. Hyatt, 1903, p. 221.
75. Reeside, 1927, p. 29.
76. Reeside, 1927, p. 30.

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EXPLANATION OF PLATES

PLATE XXVIII

FIG. 1. *Baculites compressus* var. *reesidei* Elias, n. var. Side view. Natural size. For cross section and suture of this specimen see Pl. XXXIII, figs. 2b, 2c. From Lake Creek shale member, Pierre formation, center sec. 35, T. 11 S., R. 39 W., Wallace county, Kansas.

FIG. 2. *Baculites pseudovatus* var. A Elias, n. var. Side view of holotype. Natural size. For cross section and suture of this specimen see Pl. XXXIII, figs. 5a, 5b. From Baculites zone of Salt Grass shale member, Pierre formation, E. sec. 2, T. 12 S., R. 42 W., Wallace county, Kansas.

FIG. 3. *Baculites compressus* var. *corrugatus* Elias, n. var. Side view of type specimen. Natural size. For cross section and suture of this specimen see Pl. XXXII, figs. 1a, 1b, 1c. From Lake Creek shale member, Pierre formation, SE¼ sec. 29, T. 11 S., R. 39 W., Wallace county, Kansas.

FIG. 4. *Baculites compressus* Say (in restricted sense). Side view. Natural size. For cross section and suture of this specimen see Pl. XXXII, figs. 4a, 4b, 4c. From basal part of Lake Creek shale member, Pierre formation, W. sec. 7, T. 12 S., R. 38 W., Wallace county, Kansas.

PLATE XXVIII

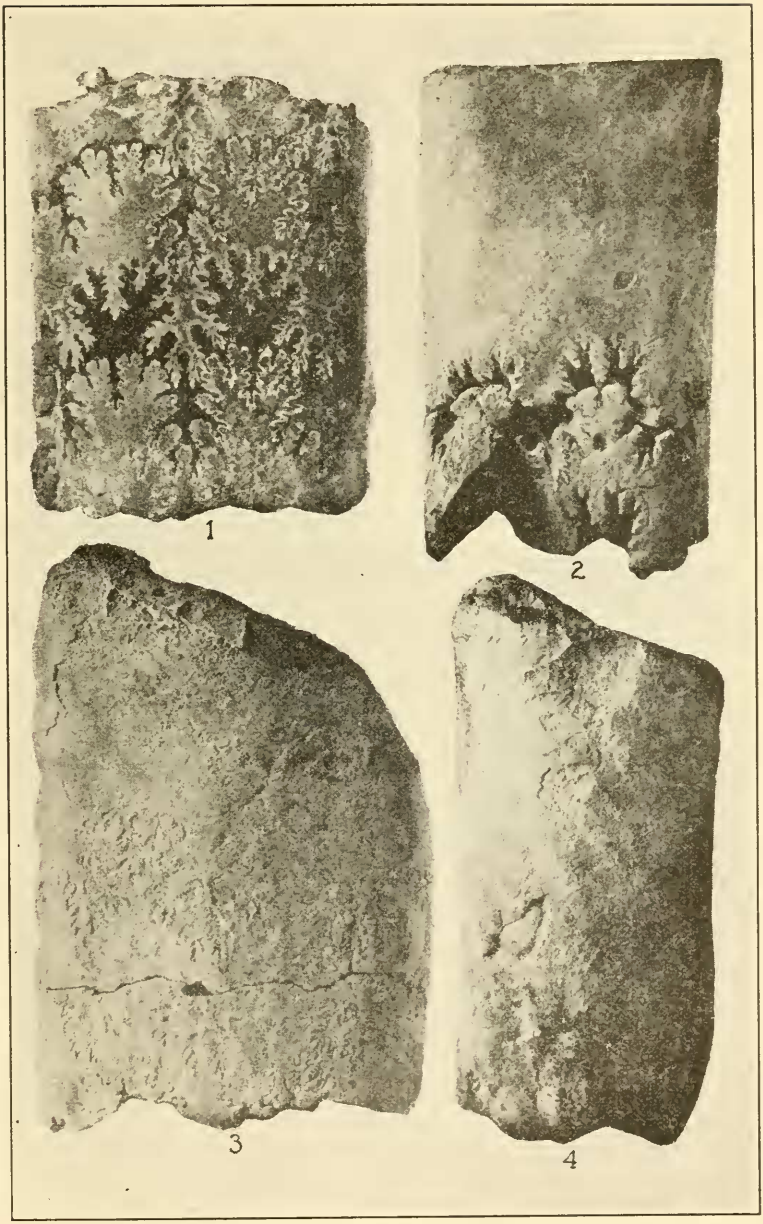


PLATE XXIX

FIGS. 1a, 1b. *Baculites pseudovatus* Elias, n. sp. Cotype. Reduced to ⅘. From upper Weskan shale member, Pierre formation, NW¼ sec. 18, T. 13 S., R. 41 W., Wallace county, Kansas. 1a, side view; 1b, siphonal view. For cross section of this specimen see Pl. XXXIII, fig. 4b.

FIG. 2. *Baculites pseudovatus* Elias, n. sp. Cotype. Natural size. From same locality. For suture and cross section of this specimen see Pl. XXXIII, figs. 4a, 4b.

FIG. 3. cf. *Discoscaphites constrictus* var. *tenuistriatus* (Kner). Natural size. From upper half of Lake Creek shale member, Pierre formation, NE¼ NE¼ sec. 8, T. 11 S., R. 38 W., Wallace county, Kansas.

PLATE XXIX

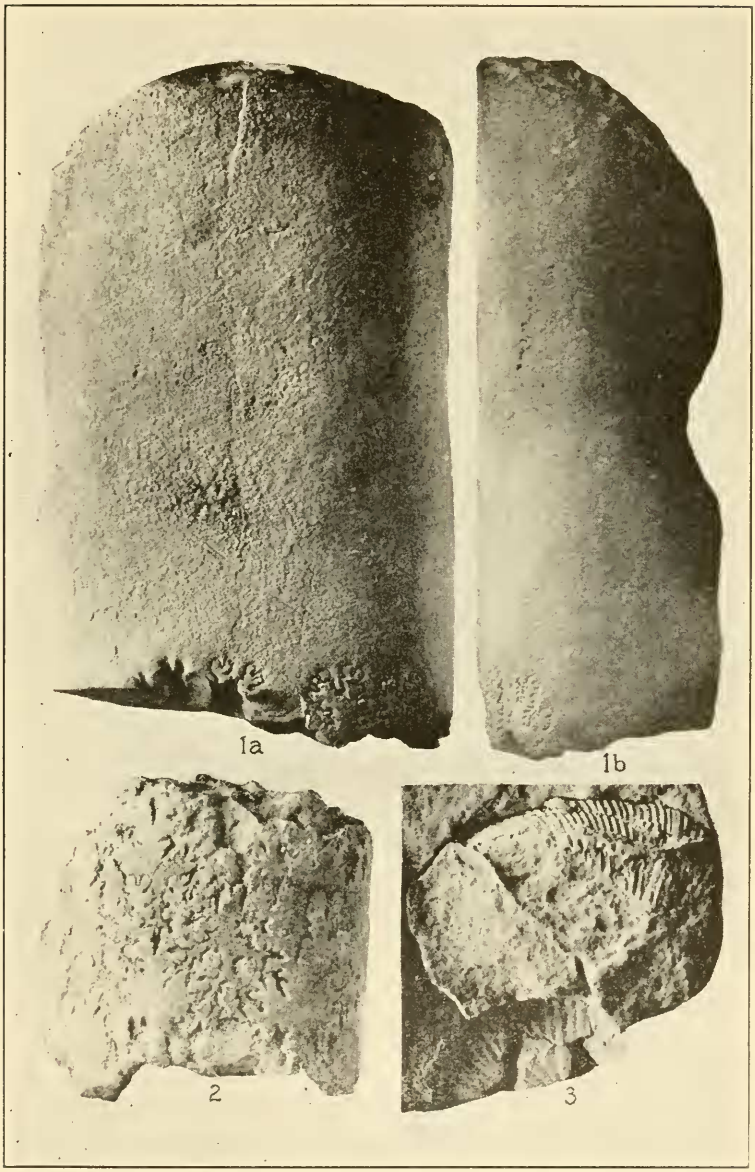


PLATE XXX

FIG. 1. *Baculites clinolobatus* Elias, n. sp. Cotype. Side view. Reduced ⅔. For suture and cross section of this specimen see Pl. XXXIV, figs. 2a, 2b. From Beecher Island shale member, Pierre formation, one-half mile northeast of Beecher Island, Yuma county, Colorado.

FIG. 2. *Baculites clinolobatus* Elias, n. sp. Cotype. Side view. Reduced ⅔. The fragment represents younger stage of the species. Found close to the specimen illustrated on figure 1.

FIG. 3. *Baculites compressus* var. *corrugatus* Elias, n. var. Side of non-septate portion of a large individual. Reduced ½. From upper part of Lake Creek shale member, Pierre formation, NW¼ SW¼ sec. 5, T. 13 S., R. 41 W., Wallace county, Kansas.

FIGS. 4a, 4b. *Baculites meeki,* n. sp. Holotype. Natural size. From Beecher Island shale member, Pierre formation, 2 miles northwest of Beecher Island, Yuma county, Colorado. 4a, side view; 4b, cross section.

PLATE XXX

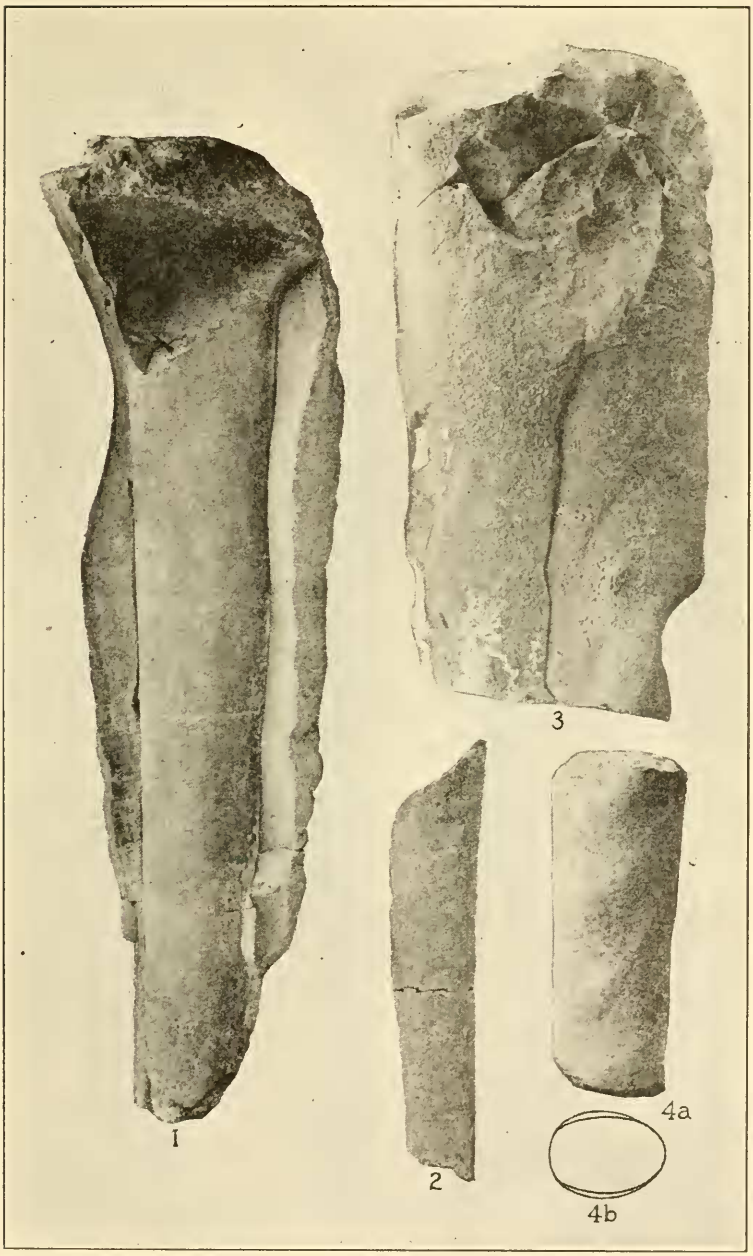


PLATE XXXI

FIGS. 1a, 1b. *Baculites grandis* Hall and Meek. Reduced ⅓. From Beecher Island shale member, Pierre formation, 1 mile northwest of Beecher Island, Yuma county, Colorado. 1a, side view; 1b, siphonal view.

FIGS. 2a, 2b. *Baculites grandis,* Hall and Meek. Reduced ⅓. From Beecher Island shale member, Pierre formation, Hackberry creek, Cheyenne county, Kansas. 2a, side view; 2b, antisiphonal view. For sutures and cross section of this specimen see Pl. XXXIV, figs. 5a, 5b, 5c.

FIG. 3. *Baculites compressus* cf. var. *reesidei* Elias, n. var. Reduced ⅕. Side view. From Lake Creek shale member, Pierre formation, center sec. 35, T. 11 S., R. 39 W., Wallace county, Kansas.

PLATE XXXI

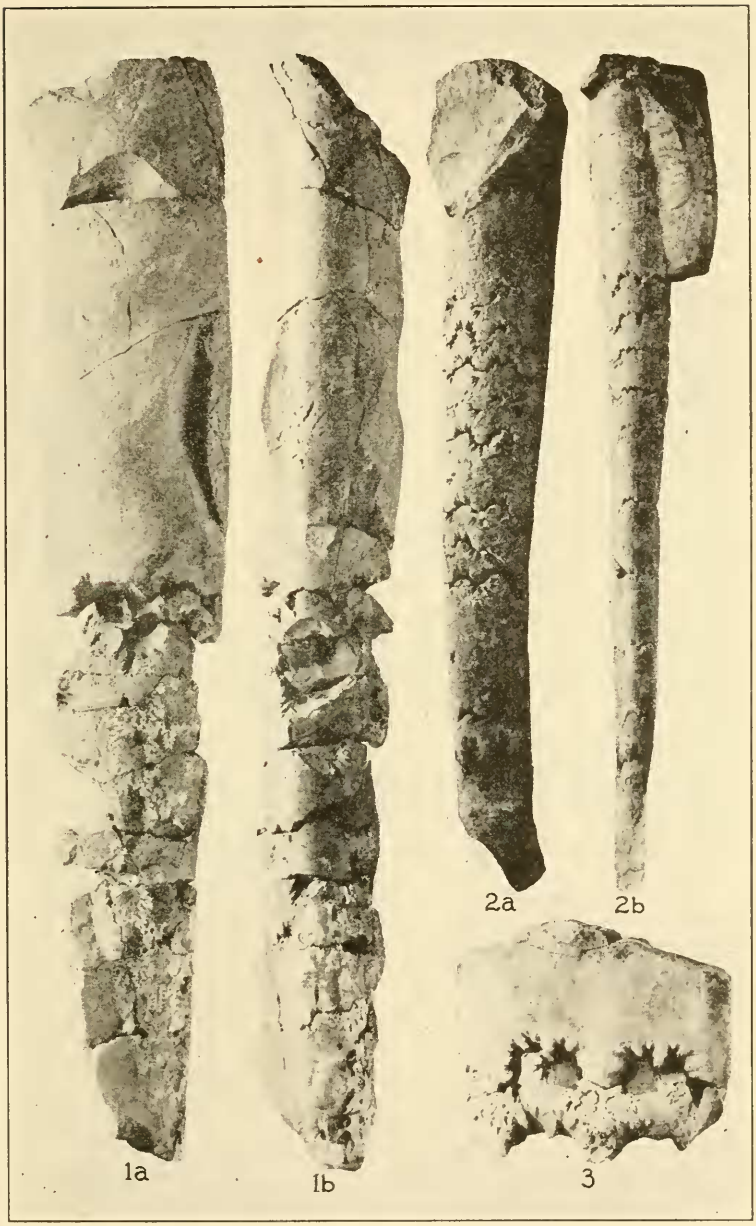


PLATE XXXII

FIGS. 1a, 1b, 1c. *Baculites compressus* var. *corrugatus* Elias, n. var. Holotype. Natural size. From Lake Creek shale member, Pierre formation, SE¼ sec. 29, T. 11 S., R. 39 W., Wallace county, Kansas. 1a, sutures; 1b, siphonal margin; 1c, cross section.

FIGS. 2a, 2b, 2c. *Baculites compressus* var. *reesidei* Elias, n. var. Type. Natural size. From Eagle sandstone in sec. 34, T. 16 N., R. 28 E., Fergus county, Montana. After J. B. Reeside, 1927, Pl. 9, figs. 1, 5. 2a, suture; 2b, siphonal margin (modified after Reeside's photograph); 2c, cross sections.

FIGS. 3a, 3b. *Baculites compressus* Say (in restricted sense). From Pierre formation in Upper Missouri exposures. After F. B. Meek, 1876, Pl. 20, figs. 30a, 30c. Suture reduced by the writer to suit the cross section, which is natural size.

FIGS. 4a, 4b, 4c. *Baculites compressus* Say (in restricted sense). Natural size. From basal part of Lake Creek shale member, Pierre formation, W. sec. 7, T. 12 S., R. 38 W., Wallace county, Kansas. 4a, suture; 4b, siphonal margin; 4c, cross section.

FIGS. 5a, 5b. *Baculites compressus* Say (in restricted sense). Natural size. From upper part of Lake Creek shale member, Pierre formation, in NW¼ SW¼ sec. 5, T. 13 S., R. 41 W., Wallace county, Kansas. 5a, suture; 5b, cross section.

PLATE XXXII

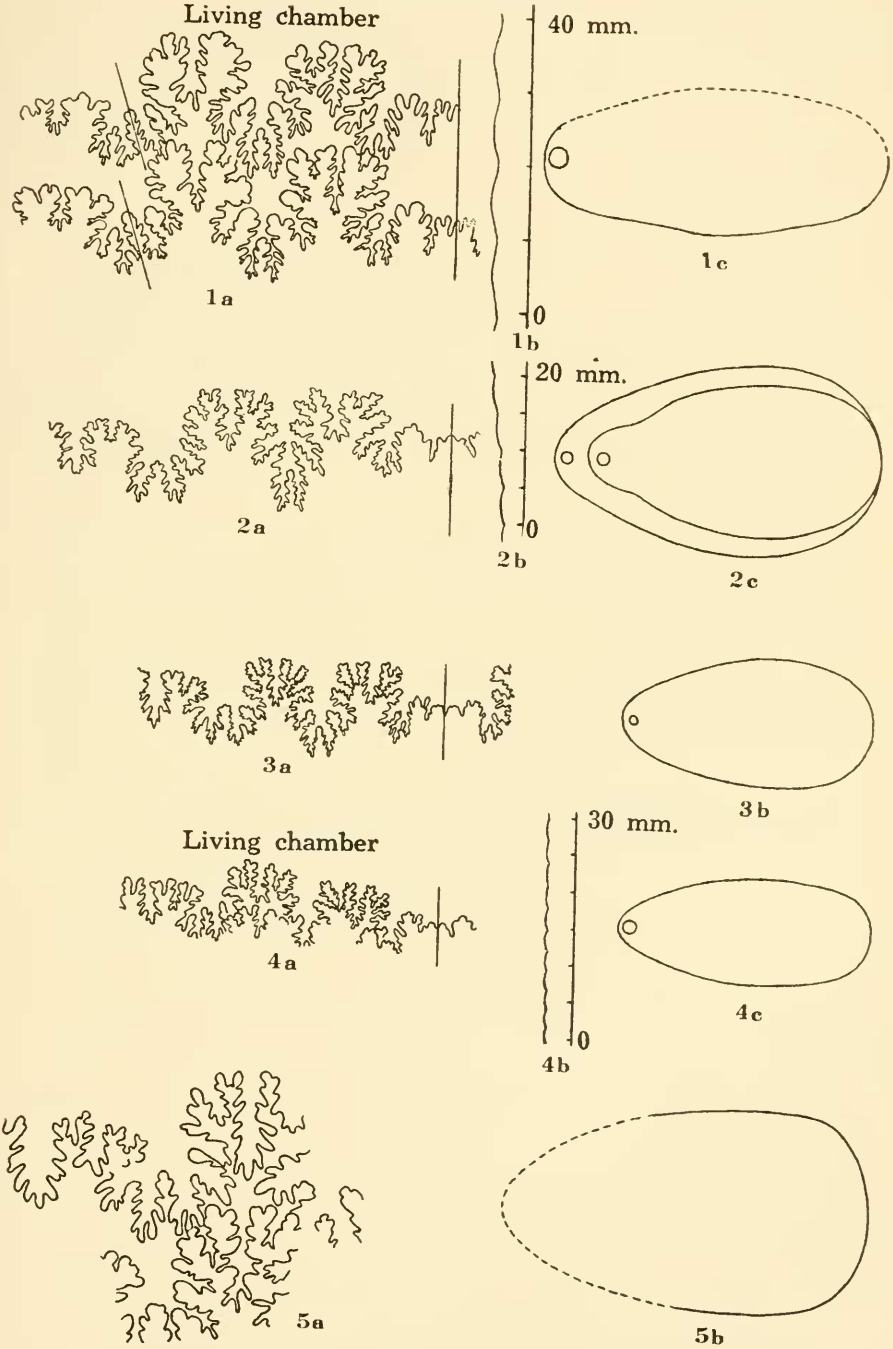

Living chamber
40 mm.
0
1a
1b
1c
20 mm.
0
2a
2b
2c
3a
3b
Living chamber
30 mm.
0
4a
4b
4c
5a
5b

PLATE XXXIII

FIGS. 1a, 1b. *Baculites compressus* cf. var. *reesidei* Elias, n. var. Natural size. From Lake Creek shale member, Pierre formation, center sec. 35, T. 11 S., R. 39 W., Wallace county, Kansas. 1a, suture; 1b, cross section.

FIGS. 2a, 2b, 2c. *Baculites compressus* var. *reesidei* Elias, n. var. Natural size. From Lake Creek shale member, Pierre formation, center sec. 35, T. 11 S., R. 39 W., Wallace county, Kansas. 2a, sutures; 2b, siphonal margin; 2c, cross section.

FIGS. 3a, 3b, 3c. *Baculites ovatus* Say. Natural size. 3a, 3b from Eagle sandstone, near top, in sec. 34, T. 16 N., R. 28 E., Fergus county, Montana. 3c from Elk Basin sandstone member of Telegraph Creek formation in T. 57 N., R. 98 W., Park county, Wyoming. After J. B. Reeside, 1927, Pl. 7, figs. 3, 5, and Pl. 6, fig. 3.

FIGS. 4a, 4b. *Baculites pseudovatus* Elias, n. sp. Cotypes. Natural size. From upper Weskan shale member, Pierre formation, NW¼ sec. 18, T. 13 S., R. 41 W., Wallace county, Kansas. 4a, suture; 4b, cross sections of two specimens.

FIGS. 5a, 5b. *Baculites pseudovatus* var. A Elias, n. var. Holotype. From Baculites zone of Salt Grass shale member, Pierre formation, E. sec. 2, T. 12 S. R. 42 W., Wallace county, Kansas. 5a, suture; 5b, cross section.

PLATE XXXIII

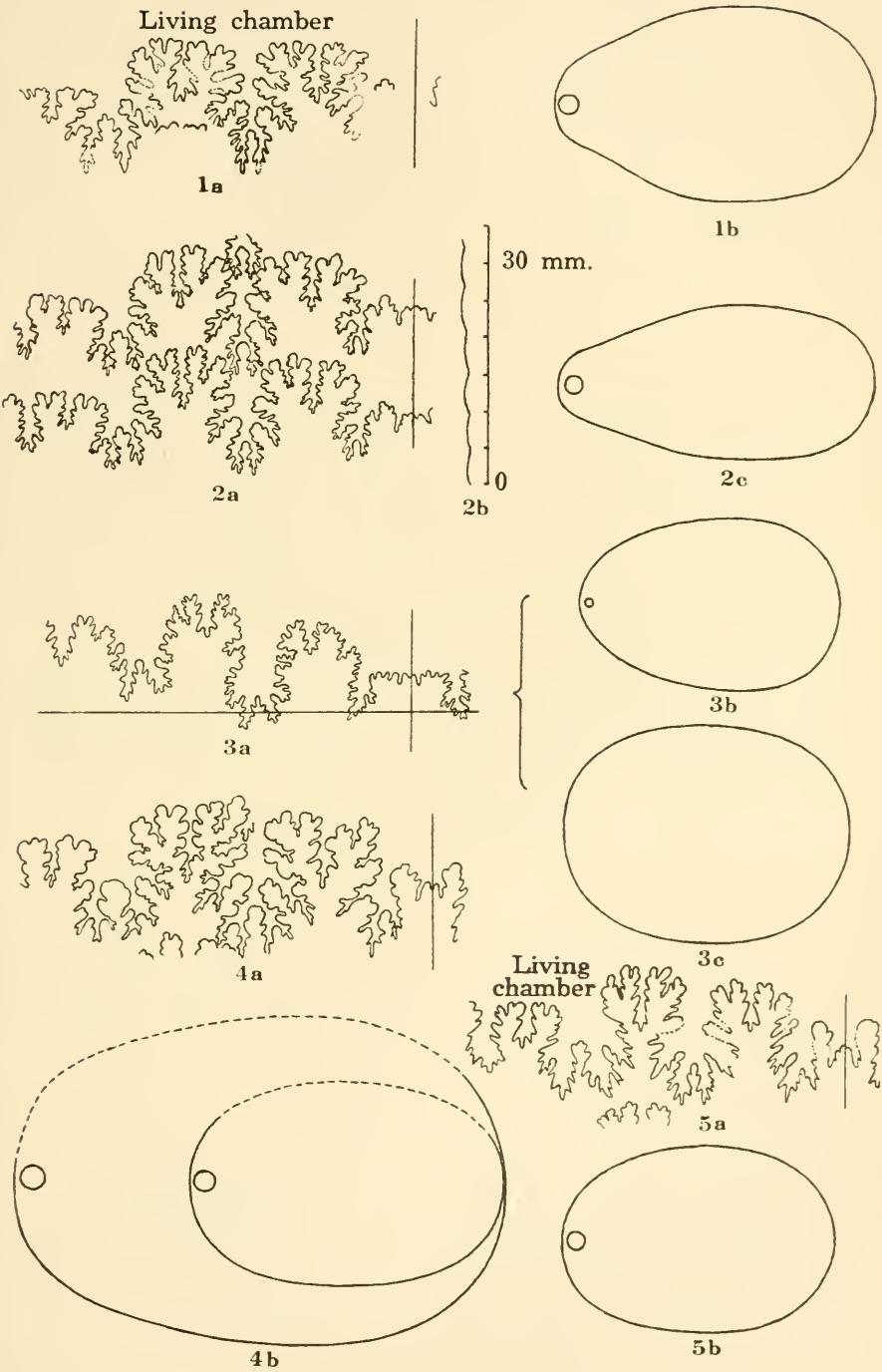


PLATE XXXIV

FIGS. 1, 2a, 2b. *Baculites clinolobatus* Elias, n. sp. Cotypes. Natural size. From Beecher Island shale member, Pierre formation, one-half mile northeast of Beecher Island, Yuma county, Colorado. 1, sutures; 2a, sutures of another specimen; 2b, cross sections of the latter.

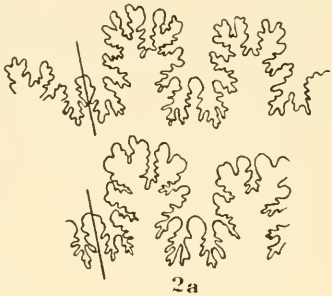
FIG. 3. *Baculites anceps* var. *leopoliensis* Novak. Natural size. Suture after Novak, 1908, p. 331, fig. 10.

FIG. 4. *Baculites grandis* Hall and Meek. Suture of large individual. Natural size. From Beecher Island shale member, Pierre formation, one-half mile northeast of Beecher Island, Yuma county, Colorado.

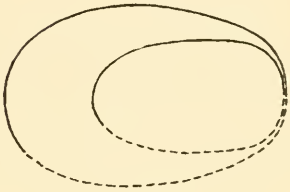
FIGS. 5a, 5b, 5c. *Baculites grandis* Hall and Meek. Natural size. From Beecher Island shale member, Pierre formation, Hackberry creek, Cheyenne county, Kansas. 5a, 5b, sutures of younger stages of the shell; 5c, cross sections of various stages of growth of the shell. Note: The larger cross section belongs to the specimen illustrated on Pl. XXXI, figs. 1a, 1b.

PLATE XXXIV

1

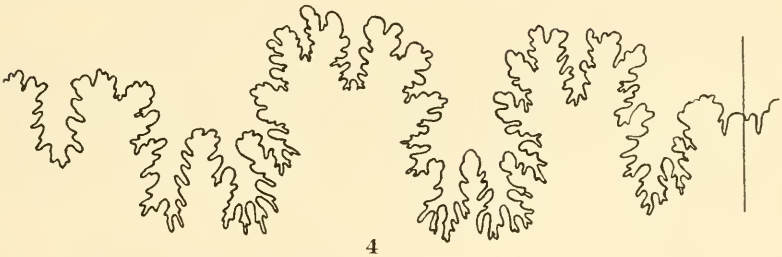


2a

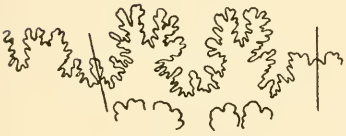


2b

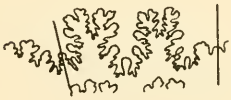
3



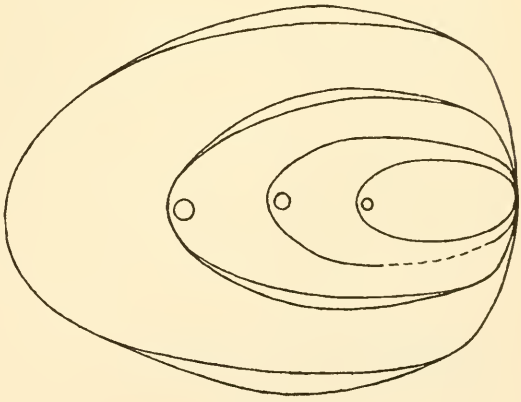
4



5a



5b



5c

PLATE XXXV

FIGS. 1a, 1b. *Baculites* cf. *pseudovatus* Elias, n. sp. Natural size. From Baculites zone, Salt Grass shale member, Pierre formation, SW¼ sec. 6, T. 13 S., R. 41 W., Wallace county, Kansas. 1a, sutures; 1b, cross section.

FIGS. 2a, 2b. *Baculites compressus* cf. var. *reesidei*, Elias, n. var. Natural size. From basal part of Salt Grass shale member, Pierre formation, NW¼ NE¼ sec. 3, T. 12 S., R. 42 W., Wallace county, Kansas.

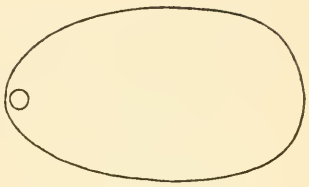
FIGS. 3a, 3b. *Baculites ovatus* var. *haresi* Reeside. Natural size. From Cody shale, 250 feet below top, in NE¼ SW¼ sec. 5, T. 50 N., R. 92 W., Big Horn county, Wyoming. After J. B. Reeside, 1927, Pl. 6, figs. 9, 10.

FIGS. 4a, 4b. *Baculites ovatus* var. *haresi* Reeside. Natural size. From basal part of Lake Creek shale member, Pierre formation, S. sec. 15, T. 12 S, R. 38 W., Wallace county, Kansas. 4a, suture; 4b, cross section.

FIGS. 5a, 5b, 5c, 5d, 5e. *Baculites compressus* cf. var. *corrugatus* Elias, n. var. Different stages of growth of a young shell. From basal part of Salt Grass shale member, Pierre formation, NW¼ NE¼ sec. 3, T. 12 S., R. 42 W., Wallace county, Kansas. 5a, cross sections, natural size. 5b, 5c, sutures, natural size; 5d, 5e, sutures, magnified 3 times. Note: The four sutures correspond to the four cross sections of figure 5a.

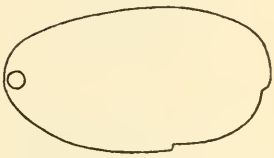
PLATE XXXV

1a

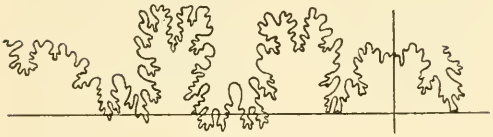


1b

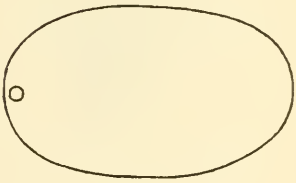
2a



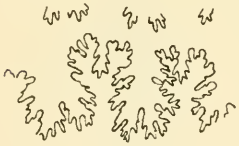
2b



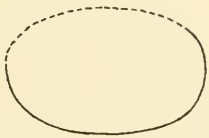
3a



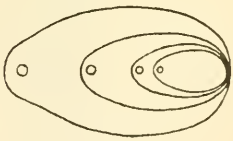
3b



4a

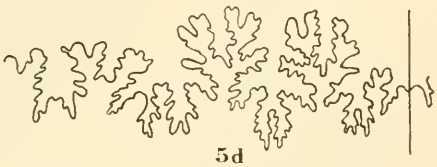


4b



5a

5b



5d

5c

5e

PLATE XXXVI

FIGS. 1a, 1b, 1c. *Scaphites plenus* Meek. Front, side and rear views. Natural size. From Pierre formation of Black Hills.

FIGS. 2a, 2b, 2c. *Scaphites plenus* Meek. Rear, side and front views. Natural size. From basal part of Salt Grass shale member, SW¼ SW¼ sec. 16, T. 13 S., R. 41 W., Wallace county, Kansas.

FIGS. 3a, 3b, 3c. *Discoscaphites nicolleti* var. *saltgrassensis* Elias, n. var. Front, rear and side views. Very slightly enlarged. From basal part of Salt Grass shale member, SE¼ sec. 2. T. 12 S., R. 42 W., Wallace county, Kansas.

PLATE XXXVI

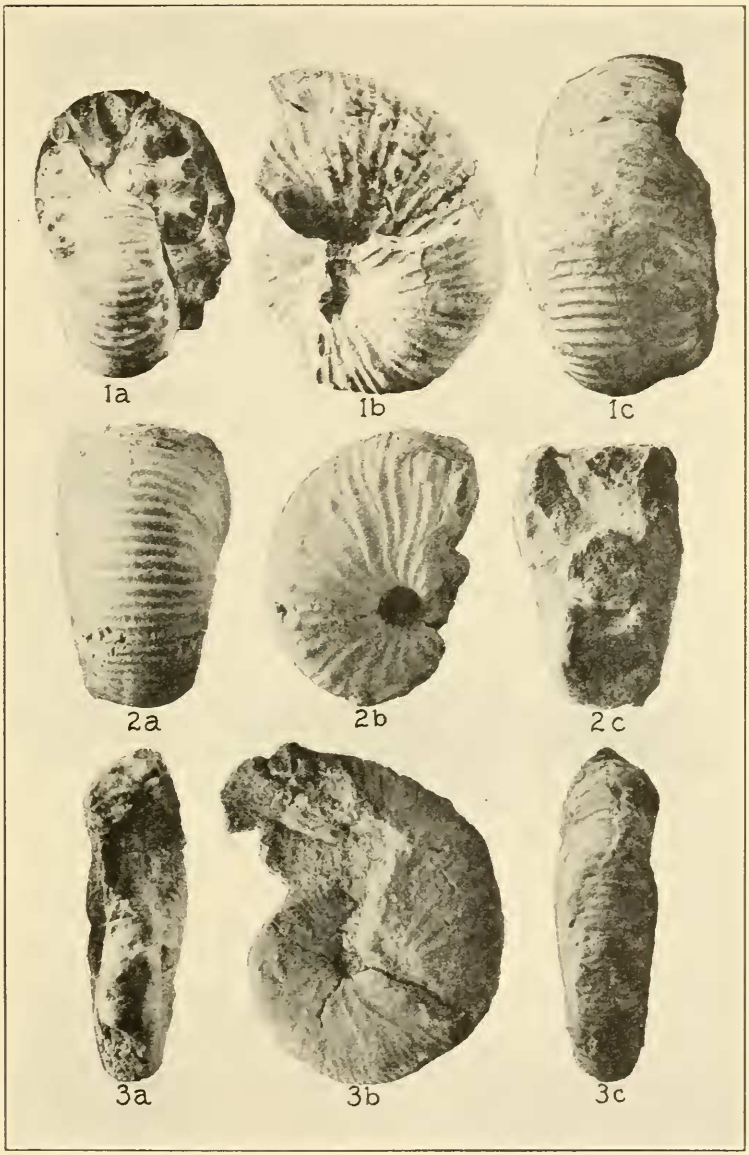


PLATE XXXVII

FIGS. 1a, 1b, 1c. *Scaphites plenus* Meek. Back, side and front views. Natural size. From Pierre shale of western South Dakota.

FIG. 2. *Acanthoscaphites nodosus* var. *brevis* Meek. Imperfect specimen in rock. From basal part of Lake Creek shale member, Pierre formation, NW¼ NE¼ sec. 8, T. 13 S., R. 41 W., Wallace county, Kansas.

FIG. 3. *Acanthoscaphites nodosus* var. *quadrangularis*. Fragment of an adult shell. Natural size. Upper part of Lake Creek shale member, sec. 12, T. 12 S., R. 39 W., Wallace county, Kansas.

PLATE XXXVII

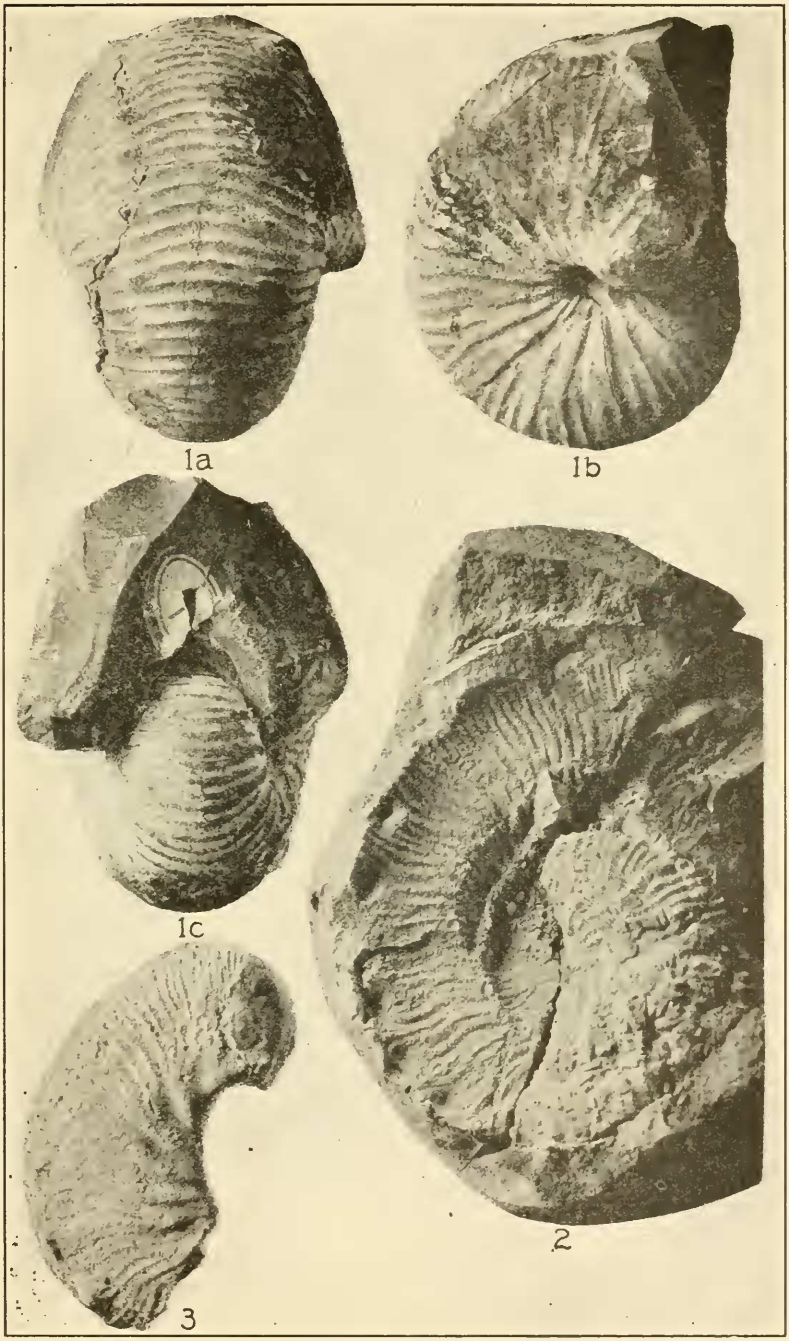


PLATE XXXVIII

FIGS. 1a, 1b, 2. *Acanthoscaphites nodosus* Say (in restricted sense). Slightly reduced. From upper part of Upper Weskan shale member, Pierre formation, NE¼ sec. 8, T. 13 S., R. 41 W., Wallace county, Kansas. 1a, side view; 1b, rear view; 2, side of internal volution of the same specimen.

FIG. 3. *Acanthoscaphites nodosus* Say (in restricted sense). Slightly reduced. From middle part of Lake Creek shale member, Pierre formation, N. sec. 13, T. 13 S., R. 41 W.

PLATE XXXVIII

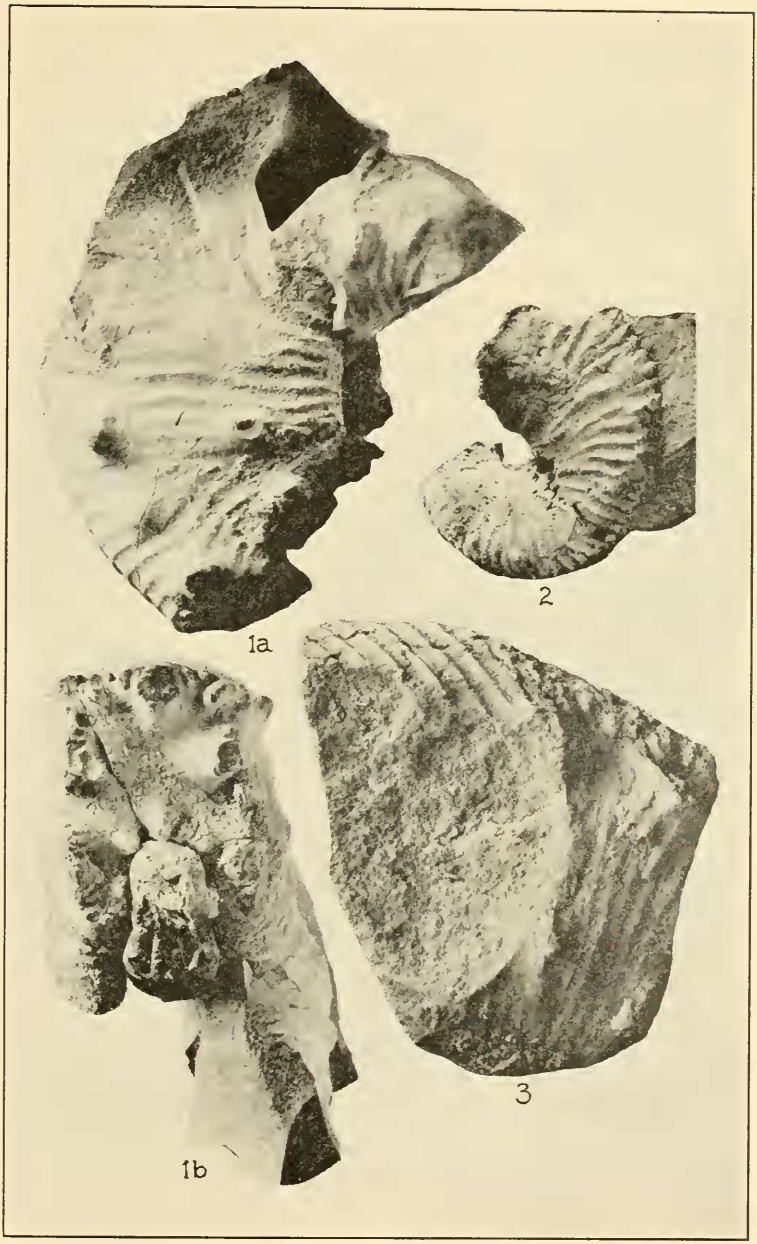


PLATE XXXIX

FIGS. 1a, 1b, 1c. *Scaphites plenus* Meek. Internal volution of the specimen illustrated on Pl. X, figs. 1a, 1b, 1c. Magnified 4/3.

FIGS. 2-5, 6a, 6b, 7, 8. *Discoscaphites abyssinus* (Morton). Natural size, except fig. 5, which is magnified 2 times. From Beecher Island shale member, Pierre formation. 2, 3, 5, 7, 8, from 2 miles northwest of Beecher Island, Yuma county, Colorado. 4, from NE¼ sec. 9, T. 2 S., R. 42 W., Cheyenne county, Kansas. 6a, 6b, from NE¼ sec. 5, T. 1 S., R. 39 W., Cheyenne county, Kansas.

FIGS. 9a, 9b. *Discoscaphites conradi* cf. var. *gulosus* (Morton). From Beecher Island shale member, Pierre formation, 2 miles northwest of Beecher Island, Yuma county, Colorado.

FIG. 10. *Discoscaphites* cf. *constrictus* var. *tenuistriatus* (Kner). Natural size. From Upper Weskan shale member, Pierre formation, center sec. 18, T. 13 S., R. 40 W., Wallace county, Kansas.

PLATE XXXIX

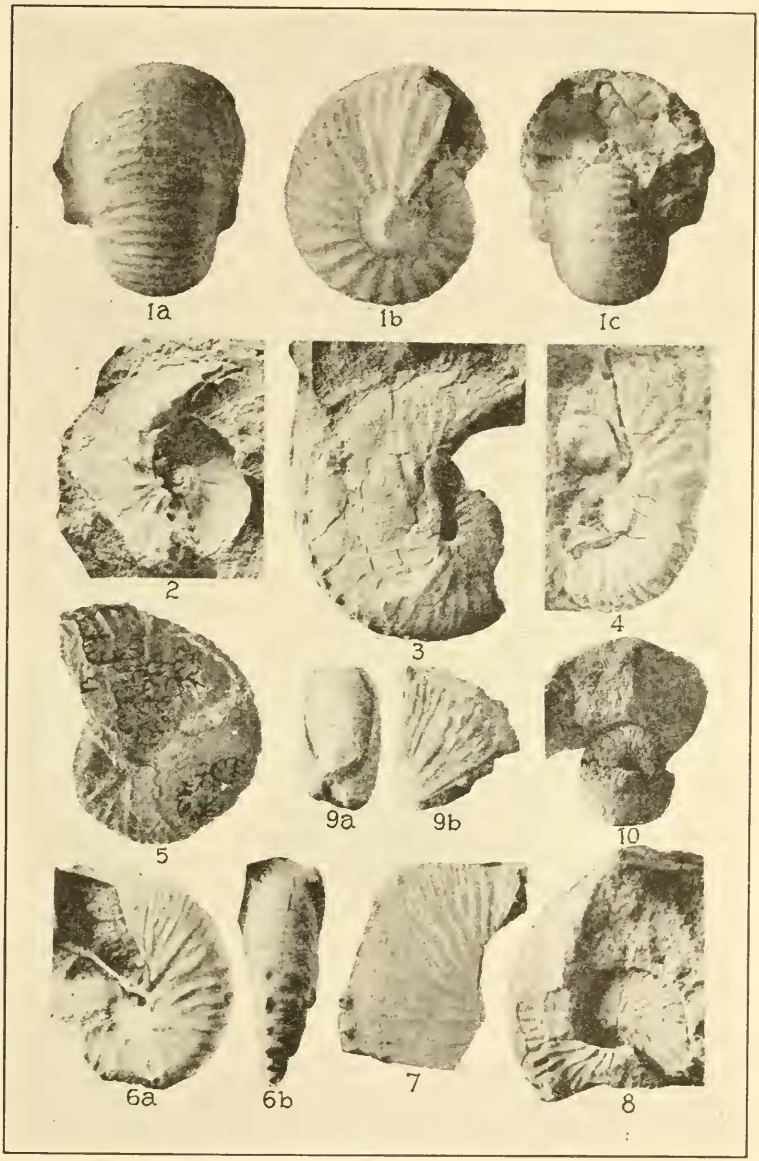


PLATE XL

FIG. 1. *Discoscaphites nicolleti* var. *saltgrassensis* Elias, n. var. Suture of the specimen illustrated on Pl. XXXVI, figs. 3a, 3b, 3c. Magnified 3 times.

FIG. 2. *Discoscaphites abyssinus* Morton. Suture of the specimen illustrated on Pl. XXXIX, fig. 5. Magnified 2 times.

FIG. 3. *Scaphites plenus* Meek. Suture of the specimen illustrated on Pl. XXXVI, figs. 1a, 1b, 1c. Slightly reduced.

FIG. 4. *Scaphites plenus* Meek. Suture of the specimen illustrated on Pl. XXXVII, figs. 1a, 1b, 1c. Slightly reduced.

FIG. 5. *Scaphites plenus* Meek. Suture of the specimen illustrated on Pl. XXXVI, figs. 2a, 2b, 2c. Magnified 3 times.

FIG. 6. *Scaphites plenus* Meek. Suture of the holotype after Meek. Probably somewhat magnified.

FIG. 7. Schematic sketch of a suture of *Baculites compressus* and allied species. SL, Siphonal lobe; 1L, 1st lateral lobe; 2L, 2d lateral lobe; AL, antisiphonal lobe; SS, siphonal saddle; 1S, 1st lateral saddle; 2S, 2d lateral saddle; 3S, 3d lateral saddle; a, stemlike body supporting the terminal branches of the 1st lateral lobe; b, median saddle of the siphonal saddle.

PLATE XL

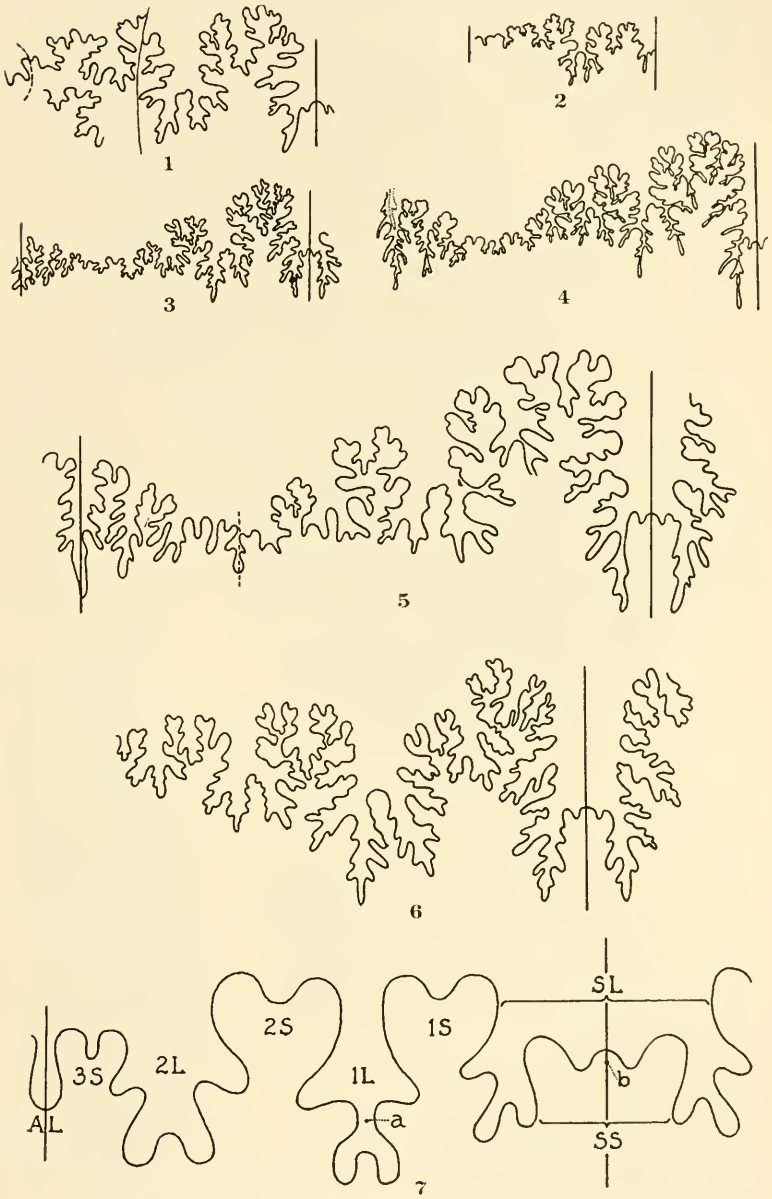


PLATE XLI

FIGS. 1a, 1b, 2. *Placenticeras meeki* Boehm. Reduced 5/12. From basal part of Upper Weskan shale member, Pierre formation, SW¼ NW¼ sec. 18, T. 13 S., R. 41 W., Wallace county, Kansas. 1a, 1b, side and dorsal veiws of septate volution. 2, side view of inner volution.

FIG. 3. *Acanthoscaphites nodosus* var. *brevis* Meek. Reduced 7/9. Side view. From lower part of Lake Creek shale member, Pierre formation, SE¼ sec. 33, T. 11 S., R. 39 W., Wallace county, Kansas.

PLATE XLI